SCIENCE

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SOME ASPECTS OF INDUSTRIAL CHEMISTRY[1]

WHILE I appreciate deeply the distinction of speaking before you on the occasion of the fiftieth anniversary of the Columbia School of Mines, I realize, at the same time, that nobody here present could do better justice to the subject which has been chosen for this lecture, than the beloved master in whose honor the Charles Frederick Chandler Lectureship has been created.

Dr. Chandler, in his long and eminently useful career as a professor and as a public servant, has assisted at the very beginning of some of the most interesting chapters of applied chemistry, here and abroad.

Some of his pupils have become leaders in chemical industry; others have found in his teachings the very conception of new chemical processes which made their names known throughout the whole world.

Industrial chemistry has been defined as "the chemistry of dollars and cents."

This rather cynical definition, in its narrower interpretation, seems to ignore entirely the far-reaching economic and civilizing influences which have been brought to life through the applications of science; it fails to do justice to the fact that the whole fabric of modern civilization becomes each day more and ever more interwoven with the endless ramifications of applied chemistry.

The earlier effects of this influence do not date back much beyond one hundred and odd years. They became distinctly evident during the first French Republic, in-

[1] An address given at Columbia University to inaugurate the Charles F. Chandler lectureship. Copyrighted by the Columbia University Press.

creased under Napoleon, gradually spread to neighboring countries, and then reaching out farther, their influence is now obvious throughout the whole world.

France, during the revolution, scattered to the winds old traditions and conventionalities, in culture as well as in politics. Until then, she had mainly impressed the world by the barbaric, wasteful splendor of her opulent kings, at whose courts the devotees of science received scant attention in comparison to the more ornamental artists and belles-lettrists, who were petted and rewarded alongside of the all-important men of the sword.

In fact, as far as the culture of science was concerned, the Netherlands, Germany and Italy, and more particularly, England, were head and shoulders above the France of "le Roi Soleil."

The struggles of the new régime put France in the awkward position of the legendary beaver which "had to climb a tree."

If for no other reason, she needed scientists to help her in her wars against the rulers of other European nations. She needed them just as much for repairing her crippled finances and her badly disturbed industries which were dependent upon natural products imported until then, but of which the supply had suddenly been cut off by the so-called Continental Blockade. Money-prizes and other inducements had been offered for stimulating the development of chemical processes, and—what is more significant—patent laws were promulgated so as to foster invention.

Nicolas Leblanc's method for the manufacture of soda to replace the imported alkalis, Berthollet's method for bleaching with chlorine, the beet-sugar industry, to replace cane sugar imported from the colonies, and several other processes, were proposed.

All these chemical processes found themselves soon lifted from the hands of the secretive alchemist or the timid pharmacist to the rank of real manufacturing methods. Industrial chemistry had begun its lusty career.

First successes stimulated new endeavors and small wonder is it that France, with these favorable conditions at hand, for a while at least, entered into the most glorious period of that part of her history which relates to the development of chemistry, and the arts dependent thereon.

It is difficult to imagine that, at that time, Germany, which now occupies such an enviable position in chemistry, was so far behind that even in 1822, when Liebig wanted to study chemistry at the best schools, he had to leave his own country, and turn to Gay-Lussac, Thénard and Dulong in Paris.

But the British were not slow to avail themselves of the new opportunities in chemical manufacturing so clearly indicated by the first successes of the French. Their linen bleacheries in Scotland and England soon used an improved method for bleaching with chloride of lime, developed by Tennant, which brought along the manufacture of other chemicals relating thereto, like sulphuric acid and soda.

The chemical reactions involved in all these processes are relatively simple, and after they were once well understood, it required mainly resourceful engineering and good commercial abilities to build up successfully the industries based thereon.

From this epoch on dates the beginning of the development of that important industry of heavy chemicals in which the British led the world for almost a century.

In the same way, England had become the leader in another important branch of chemical industry—the manufacture of coal-gas.

The Germans were soon to make up for lost time. Those same German universities which, when Liebig was a young man, were so poorly equipped for the study of chemistry, were now enthusiastically at work on research along the newer developments of the physical sciences, and, before long, the former pupils of France, in their turn, became teachers of the world.

Liebig had inaugurated for the chemical students working under him his system of research laboratories; however modest these laboratories may have been at that time, they carried bodily the study of chemistry from pedagogic boresomeness into a captivating cross-examination of nature.

And it seemed as if nature had been waiting impatiently to impart some of her secrets to the children of men, who for so many generations had tried to settle truth and knowledge by words and oratory and by brilliant displays of metaphysical controversies.

Indeed, at that time, a few kitchen tables, some clumsy glass-ware, a charcoal furnace or two, some pots and pans, and a modest balance were all that was needed to make nature give her answers.

These modest paraphernalia, eloquent by their very simplicity, brought forth rapidly succeeding discoveries. One of them was truly sensational: Liebig and Wöhler succeeded in accomplishing the direct synthesis of urea; thinking men began to realize the far-reaching import of this revolutionary discovery whereby a purely organic substance had been created in the laboratory by starting exclusively from inorganic materials. This result upset all respected doctrines that organic substances are of a special enigmatic constitution, altogether different from inorganic or mineral compounds, and that they only could be built up by the agency of the so-called "vital force"—whatever that might mean.

Research in organic chemistry became more and more fascinating; all available organic substances were being investigated one after another by restless experimentalists.

Coal-tar, heretofore a troublesome by-product of gas manufacture, notwithstanding its uninviting, ill-smelling, black sticky appearance, did not escape the general inquisitive tendency; some of its constituents, like benzol or others, were isolated and studied.

Under the brilliant leadership of Kékulé, a successful attempt was made to correlate the rapidly increasing new experimental observations in organic chemistry into a new theory which would try to explain all the numerous facts; a theory which became the sign-post to the roads of further achievements.

The discovery of quickly succeeding processes for making from coal-tar derivatives numerous artificial dyes, rivaling, if not surpassing, the most brilliant colors of nature, made the group of bold investigators still bolder. Research in organic chemistry began to find rapid rewards; entirely new and successful industries based on purely scientific data were springing up in England and France, as well as in Germany.

Some wide-awake leaders of these new enterprises, more particularly in Germany, soon learned that they were never hampered by too much knowledge, but that, on the contrary, they were almost continuously handicapped in their impatient onward march by insufficient knowledge, or by misleading conceptions, if not by incorrect published facts.

This is precisely where the study of organic chemistry received its greatest stimulating influence and soon put Ger-

many in this branch of science, ahead of all other nations.

Money and effort had to be spent freely for further research. The best scholars in chemistry were called into action. Some men, who were preparing themselves to become professors, were induced to take a leading part as directors in one or another of the new chemical enterprises. Others, who refused to forsake their teachers' career, were retained as advisers or guides, and, in several instances, the honor of being the discoverers of new processes, or a new dye, was made more substantial by financial rewards. The modest German university professor, who heretofore had lived within a rather narrow academic sphere, went through a process of evolution, where the rapidly growing chemical industry made him realize his latent powers and greater importance, and broadened his influence far beyond the confines of his lecture-room. Even if he were altruistic enough to remain indifferent to fame or money, he felt stimulated by the very thought that he was helping, in a direct manner, to build up the nation and the world through the immediate application of the principles of science.

In the beginning, science did all the giving and chemical industry got most of the rewards; but soon the rôles began to change to the point where frequently they became entirely inverted. The universities did not furnish knowledge fast enough to keep pace with the requirements of the rapidly developing new industries. Modern research laboratories were organized by some large chemical factories on a scale never conceived before, with a lavishness which made the best equipped university laboratory appear like a timid attempt. Germany, so long behind France and England, had become the recognized leader in organic manufacturing processes, and developed a new industrial chemistry based more on the thorough knowledge of organic chemistry than on engineering skill.

In this relation, it is worth while to point out that the early organic industrial chemistry, through which Germany was soon to become so important, at first counted its output not in tons, but in pounds—not in size nor in quantity, but in variety and quality.

Now let us see how Germany won her spurs in chemical engineering as well:

At the beginning, the manufacturing problems in organic chemistry involved few, if any, serious engineering difficulties, but required, most of all, a sound theoretical knowledge of the subject; this put a premium on the scientist, and could afford, for awhile at least, to ignore the engineer. But when growing developments began to claim the help of good engineers, there was no difficulty whatsoever in supplying them, nor in making them cooperate with the scientists. In fact, since then, Germany has solved, just as successfully, some of the most extraordinary chemical engineering problems ever undertaken, although the development of such processes was entered upon at first from the purely scientific side.

In almost every case, it was only after the underlying scientific facts had been well established, that any attempt was made to develop them commercially.

Healthy commercial development of new scientific processes does not build its hope of success upon the cooperation of that class of "promoters" which are always eager to find any available pretext for making "quick money," and whose scientific ignorance contributes conveniently to their comfort by not interfering too much with their self-assurance and their voluble assertions. The history of most of the successful recent chemical processes abounds in examples where, even after the under-

lying principles were well established, long and costly preparatory team-work had to be undertaken; where foremost scientists, as well as engineers of great ability, had to combine their knowledge, their skill, their perseverance, with the support of large chemical companies, who, in their turn, could rely on the financial backing of strong banking concerns, well advised by tried expert specialists.

History does not record how many processes thus submitted to careful study were rejected because, on close examination, they were found to possess some hopeless shortcomings. In this way, numerous fruitless efforts and financial losses were averted, where less carefully accumulated knowledge might have induced less scrupulous promoters to secure money for plausible but ill-advised enterprises.

In the history of the manufacture of artificial dyes, no chapter gives a more striking instances of long, assiduous and expensive preliminary work of the highest order than the development of the industrial synthesis of indigo. Here was a substance of enormous consumption which, until then, had been obtained from the tropics as a natural product of agriculture.

Professor von Baeyer and his pupils, by long and marvelously clever laboratory work, had succeeded in unraveling the chemical constitution of this indigo dye, and had finally indicated some possible methods of synthesis. Notwithstanding all this, it took the Badische Aniline & Soda Fabrik about twenty years of patient research work, carried out by a group of eminent chemists and engineers, before a satisfactory method was devised by which the artificial product could compete in price and in quality with natural indigo.

Germany, with her well-administered and easily enforcible patent laws, has added, through this very agency, a most vital inducement for pioneer work in chemical industries. Who otherwise would dare to take the risk of all the expenses connected with this class of creative work? Moreover, who would be induced to publish the result of his discoveries far and wide throughout the whole world in that steadily flowing stream of patent literature, which, much sooner than any text-books or periodicals, enables one worker to be benefited and to be inspired by the publication of the latest work of others?

The development of some problems of industrial chemistry has enlisted the brilliant collaboration of men of so many different nationalities that the final success could not, with any measure of justice, be ascribed exclusively to one single race or nation; this is best illustrated by the invention of the different methods for the fixation of nitrogen from the air.

This extraordinary achievement, although scarcely a few years old, seems already an ordinary link in the chain of common, current events of our busy life; and yet, the facts connected with this recent conquest reveal a modern tale of great deeds of the race—an epos of applied science.

Its story began the day when chemistry taught us how indispensable are the nitrogeneous substances for the growth of all living beings.

Generally speaking, the most expensive food-stuffs are precisely those which contain most nitrogen; for the simple reason that there is, and always has been, at some time or another, a shortage of nitrogeneous foods in the world. Agriculture furnishes us these proteid- or nitrogen-containing bodies, whether we eat them directly as vegetable products, or indirectly as animals which have assimilated the proteids from plants. It so happens, however, that by our ill-balanced methods of agriculture, we take nitrogen from the soil much faster

than it is supplied to the soil through natural agencies. We have tried to remedy this discrepancy by enriching the soil with manure or other fertilizers, but this has been found totally insufficient, especially with our methods of intensive culture—our fields want more nitrogen. So agriculture has been looking anxiously around to find new sources of nitrogen fertilizer. For a short time, an excellent supply was found in the guano deposits of Peru; but this material was used up so eagerly that the supply lasted only a very few years. In the meantime, the ammonium salts recovered from the by-products of the gas-works have come into steady use as nitrogen fertilizer. But, here again, the supply is entirely insufficient, and during the later period our main reliance has been placed on the natural beds of sodium nitrate, which are found in the desert regions of Chile. This has been, of late, our principal source of nitrogen for agriculture, as well as for the many industries which require saltpeter or nitric acid.

In 1898, Sir William Crookes, in his memorable presidential address before the British Association for the Advancement of Science, called our attention to the threatening fact that, at the increasing rate of consumption, the nitrate beds of Chile would be exhausted before the middle of this century. Here was a warning—an alarm call—raised to the human race by one of the deepest scientific thinkers of our generation. It meant no more nor less than that before long our race would be confronted with nitrogen starvation. In a given country, all other conditions being equal, the abundance or the lack of nitrogen available for nutrition is a paramount factor in the degree of general welfare, or of physical decadence. The less nitrogen there is available as food-stuffs, the nearer the population is to starvation. The great famines in such nitrogen-deficient countries as India and China and Russia are sad examples of nitrogen starvation.

And yet, nitrogen, as such, is so abundant in nature that it constitutes four fifths of the air we breathe. Every square mile of our atmosphere contains nitrogen enough to satisfy our total present consumption for over half a century. However, this nitrogen is unavailable as long as we do not find means to make it enter into some suitable chemical combination. Moreover, nitrogen was generally considered inactive, and inert, because it does not enter readily in chemical combination.

William Crookes's disquieting message of rapidly approaching nitrogen starvation did not cause much worry to politicians—they seldom look so far ahead into the future. But, to the men of science, it rang like a reproach to the human race. Here, then, we were in possession of an inexhaustible store of nitrogen in the air, and yet, unless we found some practical means for tying some of it into a suitable chemical combination, we should soon be in a position similar to that of a shipwrecked sailor, drifting around on an immense ocean of brine, and yet slowly dying for lack of drinking water.

As a guiding beacon, there was, however, that simple experiment, carried out in a little glass tube, as far back as 1785, by both Cavendish and Priestley, which showed that if electric sparks were passed through air, the oxygen thereof was able to burn some of the nitrogen and to engender nitrous vapors.

This seemingly unimportant laboratory curiosity, so long dormant in the text-books, was made a starting point by Charles S. Bradley and D. R. Lovejoy, in Niagara Falls, for creating the first industrial apparatus for converting the nitrogen of the

air into nitric acid by means of the electric arc.

As early as 1902, they published their results as well as the details of their apparatus. Although they operated only one full-sized unit, they demonstrated conclusively that nitric acid could thus be produced from the air in unlimited quantities. We shall examine later the reasons why this pioneer enterprise did not prove a commercial success; but to these two American inventors belongs, undoubtedly, the credit of having furnished the first answer to the distress call of Sir William Crookes.

In the meantime, many other investigators were at work at the same problem, and soon from Norway's abundant waterfalls came the news that Birkeland and Eyde had solved successfully, and on a commercial scale, the same problem by a differently constructed apparatus. The Germans, too, were working on the same subject, and we heard that Schoenherr, also Pauling, had evolved still other methods, all, however, based on the Cavendish-Priestley principle of oxidation of nitrogen. In Norway alone the artificial salpeter factories use now, day and night, over 200,000 electrical horse-power, which will soon be doubled; while a further addition is contemplated which will bring the volume of electric current consumed to about 500,000 horse-power. The capital invested at present in these works amounts to $27,000,000.

Frank and Caro, in Germany, succeeded in creating another profitable industrial process whereby nitrogen could be fixed by carbide of calcium, which converts it into calcium cyanamide, an excellent fertilizer by itself. By the action of steam on cyanamide, ammonia is produced, or it can be made the starting point of the manufacture of cyanides, so profusely used for the treatment of gold and silver ores.

Although the synthetic nitrates have found a field of their own, their utilization for fertilizers is smaller than that of the cyanamide; and the latter industry represents, to-day, an investment of about $30,000,000, with three factories in Germany, two in Norway, two in Sweden, one in France, one in Switzerland, two in Italy, one in Austria, one in Japan, one in Canada, but not any in the United States. The total output of cyanamide is valued at $15,000,000 yearly and employs 200,000 horse-power, and preparations are made at almost every existing plant for further extensions. An English company is contemplating the application of 1,000,000 horse-power to the production of cyanamide and its derivatives, 600,000 of which have been secured in Norway and 400,000 in Iceland.

But still other processes are being developed, based on the fact that certain metals or metalloids can absorb nitrogen, and can thus be converted into nitrides; the latter can either be used directly as fertilizers or they can be made to produce ammonia under suitable treatment.

The most important of these nitride processes seems to be that of Serpek, who, in his experimental factory at Niedermorschweiler, succeeded in obtaining aluminum nitride in almost theoretical quantities, with the use of an amount of electrical energy eight times less than that needed for the Birkeland-Eyde process and one half less than for the cyanamide process, the results being calculated for equal weights of "fixed" nitrogen.

A French company has taken up the commercial application of this process which can furnish, besides ammonia, pure alumina for the manufacture of aluminum metal.

An exceptionally ingenious process for the direct synthesis of ammonia, by the

direct union of hydrogen with nitrogen, has been developed by Haber in conjunction with the chemists and engineers of the Badische Aniline & Soda Fabrik.

The process has the advantage that it is not, like the other nitrogen-fixation processes, paramountly dependent upon cheap power; for this reason, if for no other, it seems to be destined to a more ready application. The fact that the group of the three German chemical companies which control the process have sold out their former holdings in the Norwegian enterprises to a Norwegian-French group, and are now devoting their energies to the commercial installation of the Haber process, has quite some significance as to expectation for the future.

The question naturally arises: Will there be an over-production and will these different rival processes not kill each other in slaughtering prices beyond remunerative production?

As to over-production, we should bear in mind that nitrogen fertilizers are already used at the rate of about $200,000,000 worth a year, and that any decrease in price, and, more particularly, better education in farming, will probably lead to an enormously increased consumption. It is worth mentioning here that in 1825, the first shipload of Chile saltpeter, which was sent to Europe, could find no buyer, and was finally thrown into the sea as useless material.

Then again, processes for nitric acid and processes for ammonia, instead of interfering, are supplementary to each other, because the world needs ammonia and ammonium salts, as well as nitric acid or nitrates.

It should be pointed out also, that, ultimately, the production of ammonium nitrate may prove the most desirable method so as to minimize freight; for this salt contains much more nitrogen to the ton than is the case with the more bulky calcium-salt, under which form synthetic nitrates are now put into the market.

Before leaving this subject, let us examine why Bradley and Lovejoy's efforts came to a standstill where others succeeded.

First of all, the cost of power at Niagara Falls is three to five times higher than in Norway, and although at the time this was not strictly prohibitive for the manufacture of nitric acid, it was entirely beyond hope for the production of fertilizers. The relatively high cost of power in our country is the reason why the cyanamide enterprise had to locate on the Canadian side of Niagara Falls, and why, up till now, outside of an experimental plant in the South (a 4,000 horse-power installation in North Carolina, using the Pauling process), the whole United States has not a single synthetic nitrogen fertilizer works.

The yields of the Bradley-Lovejoy apparatus were rather good. They succeeded in converting as much as two and one half per cent. of the air, which is somewhat better than their successors are able to accomplish.

But their units, 12 kilowatts, were very much smaller than the 1,000 to 3,000 kilowatts now used in Norway; they were also more delicate to handle, all of which made installation and operation considerably more expensive.

However this was the natural phase through which any pioneer industrial development has to go, and it is more than probable that in the natural order of events, these imperfections would have been eliminated.

But the killing stroke came when financial support was suddenly withdrawn.

In the successful solution of similar industrial problems, the originators in Europe were not only backed by scientif-

ically well-advised bankers, but they were helped to the rapid solution of all the side problems by a group of specially selected scientific collaborators, as well as by all the resourcefulness of well-established chemical enterprises.

That such conditions are possible in the United States has been demonstrated by the splendid team-work which led to the development of the modern Tungsten lamp in the research laboratories of the General Electric Company, and to the development of the Tesla polyphase motor, by the group of engineers of the Westinghouse Company.

True, there are endless subjects of research and development which can be brought to success by the efforts of single independent inventors, but there are some problems of applied science which are so vast, so much surrounded with ramifying difficulties, that no one man, nor two men, however exceptional, can either furnish the brains or the money necessary for leading to success within a reasonable time. For such special problems, the rapid cooperation of numerous experts and the financial resources of large establishments are indispensable.

All these examples of the struggle for efficiency and improvement demonstrate why, in industrial chemistry, the question of *dollars and cents* has to be taken very much into consideration.

From this standpoint at least, the "dollars and cents" argument can be interpreted as a symptom of industrial efficiency, and thus, the definition sounds no longer as a reproach. With some allowable degree of accuracy, it formulates one of the economic aspects of any acceptable industrial chemical process.

Indeed, barring special conditions, as, for instance, incompetent or reckless management, unfair competition, monopolies, or other artificial privileges, the money success of a chemical process is the cash plebiscite of approval of the consumers. It is bound, after a time at least, to weed out the inefficient methods.

Some chemists, who have little or no experience with industrial enterprises, are too much over-inclined to judge a chemical process exclusively from the standpoint of the chemical reactions involved therein, without sufficient regard to engineering difficulties, financial requirements, labor problems, market and trade conditions, rapid development of the art involving frequent disturbing improvements in methods and expensive changes in equipment, advantages or disadvantages of the location of the plant, and other conditions so numerous and variable that many of them can hardly be foreseen even by men of experience.

And yet, these seemingly secondary considerations most of the time become the deciding factor of success or failure of an otherwise well-conceived chemical process.

The cost of transportation alone will, frequently, decide whether a certain chemical process is economically possible or not. For instance, the big Washoe Smelter, in Montana, wastes enough sulphuric-dioxide gas to make daily 1,800 tons of sulphuric acid, but that smelter is too far distant from any possible market for such a quantity of otherwise valuable material.

Another example of the kind is found in the natural deposits of soda or soda lakes in California. One of these soda lakes contains from thirty to forty-two million tons of soda. Here is a natural source of supply which would be ample to satisfy the world's demand for many years to come. Similar deposits exist in other parts of the world, but the cost of transportation to a sufficiently large and profitable market is so exorbitant that, in the meantime, it is cheaper to erect at more convenient points

expensive chemical works in which soda is made chemically and from where the market can be supplied more profitably.

In addition, we can cite the artificial nitrate processes in Norway, which, notwithstanding their low efficiency and expensive installation, can furnish nitrate in competition with the natural nitrate beds of Chile, because the latter are hampered by the cost of extraction from the soil where fuel for crystallization is expensive, in addition to the considerable cost of freight.

But there is no better example illustrating the far-reaching effect of seemingly secondary conditions upon the success of a chemical process than the history of the Leblanc soda process.

This famous process was the forerunner of chemical industry. For almost a century it dominated the enormous group of industries of heavy chemicals, so expressively called by the French "La Grande Industrie Chimique," and now we are witnesses of the lingering death agonies of this chemical colossus. Through the Leblanc process, large fortunes have been made and lost; but even after its death, it will leave a treasure of information to science and chemical engineering, the value of which can hardly be overestimated.

Here, then, is a very well worked-out process, admirably studied in all its details, which, in its heroic struggle for existence, has drawn upon every conceivable resource of ingenuity furnished by the most learned chemists and the most skilful engineers, who succeeded in bringing it to an extraordinary degree of perfection, and which, nevertheless, has to succumb before inexorable, although seemingly secondary, conditions.

Strange to say, its competitor, the Solvay process, entered into the arena after a succession of failures. When Solvay, as a young man, took up this process, he was, himself, totally ignorant of the fact that no less than about a dozen able chemists had invented and reinvented the very reaction on which he had pinned his faith; that, furthermore, some had tried it on a commercial scale, and had, in every instance, encountered failure. At that time, all this must, undoubtedly, have been to young Solvay a revelation sufficient to dishearten almost anybody. But he had one predominant thought to which he clung as a last hope of success, and which would probably have escaped most chemists; he reasoned that, in this process, he starts from two watery solutions, which, when brought together, precipitate a dry product, bicarbonate of soda; in the Leblanc process, the raw materials must be melted together, with the use of expensive fuel, after which the mass is dissolved in water, losing all these valuable heat units, while more heat has again to be applied to evaporate to dryness.

After all, most of the weakness of the Leblanc process resides in the greater consumption of fuel. But the cost of fuel, here again, is determined by freight rates. This is so true that we find that the last few Leblanc works which manage to keep alive are exactly those which are situated near unusually favorable shipping points, where they can obtain cheap fuel, as well as cheap raw materials, and whence they can most advantageously reach certain profitable markets.

But another tremendous handicap of the Leblanc process is that it gives as one of its by-products, hydrochloric acid. Profitable use for this acid, as such, can be found only to a limited extent. It is true that hydrochloric acid could be used in much larger quantities for many purposes where sulphuric acid is used now, but it has, against sulphuric acid, a great freight disadvantage. In its commercially available

condition, it is an aqueous solution, containing only about one third of real acid, so that the transportation of one ton of acid practically involves the extra cost of freight of about two tons of water. Furthermore, the transportation of hydrochloric acid in anything but glass carboys involves very difficult problems in itself, so that the market for hydrochloric acid remains always within a relatively small zone from its point of production. However, for awhile at least, an outlet for this hydrochloric acid was found by converting it into a dry material which can easily be transported; namely, chloride of lime or bleaching-powder.

The amount of bleaching-powder consumed in the world practically dictated the limited extent to which the Leblanc process could be profitably worked in competition with the Solvay process. But even this outlet has been blocked during these later years by the advent of the electrolytic alkali processes, which have sprung up successfully in several countries, and which give as a cheap by-product, chlorine, which is directly converted into chloride of lime.

To-day, any process which involves the production of large quantities of hydrochloric acid, beyond what the market can absorb as such, or as derivatives thereof, becomes a positive detriment, and foretells failure of the process. Even if we could afford to lose all the acid, the disposal of large quantities thereof conflicts immediately with laws and ordinances relative to the pollution of the atmosphere or streams, or the rights of neighbors, and occasions expensive damage suits.

Whatever is said about hydrochloric acid applies to some extent to chlorine, produced in the electrolytic manufacture of caustic soda. Here again, the development of the latter industry is limited, primarily, by the amount of chlorine which the market, as such, or as chlorinated products, can absorb.

At any rate, chlorine can be produced so much cheaper by electrolytic caustic alkali processes than formerly, and in the meantime the market price of chloride of lime has already been cut about in half.

In as far as the rather young electrolytic alkali industry has taken a considerable development in the United States, let us examine it somewhat nearer.

At present, the world's production of chloride of lime approximates about half a million tons.

We used to import all our chloride of lime from Europe, until about fifteen years ago, when the first successful electrolytic alkali works were started at Niagara Falls. That ingenious mercury cell of Hamilton Y. Castner—a pupil of Professor Chandler and one of the illustrious sons of the Columbia School of Mines—was first used, and his process still furnishes a large part of all the electrolytic caustic soda and chlorine manufactured here and abroad.

At present, about 30,000 electrical horsepower are employed uninterruptedly for the different processes used in the United States, and our home production has increased to the point where, instead of importing chloride of lime, we shall soon be compelled to export our surplus production.

It looks now as if, for the moment at least, any sudden considerable increase in the production of chloride of lime would lead to over-production until new channels of consumption of chloride of lime or other chlorine products can be found.

However, new uses for chlorine are being found every day. The very fact that commercial hydrochloric acid of exceptional purity is now being manufactured in Niagara Falls by starting from chlorine, indicates clearly that conditions are being reversed; no longer than a few years ago,

when chlorine was manufactured exclusively by means of hydrochloric acid, this would have sounded like a paradox.

The consumption of chlorine for the preparation of organic chlorination products utilized in the dye-stuff industry, is also increasing continually, and its use for the manufacture of tetrachloride of carbon and so-called acetylen chlorination products, has reached quité some importance.

There is probably a much overlooked but wider opening for chlorinated solvents in the fact that ethylen-gas can be prepared now at considerably lower cost than acetylen, and that ethylen-chloride, or the old known "Dutch Liquid," is an unusually good solvent. It has, furthermore, the great advantage that its specific gravity is not too high, and its boiling point, too, is about the right temperature. It ought to be possible to make it at such a low price that it would find endless applications where the use of other chlorination solvents has thus far been impossible.

The chlorination of ores for certain metallurgical processes may eventually open a still larger field of consumption for chlorine.

In the meantime, liquified chlorine gas, obtained by great compression, or by intense refrigeration, has become an important article of commerce, which can be transported in strong steel cylinders. Its main utilization resides in the manufacture of tin chloride by the Goldschmidt process for reclaiming tin-scrap. It is finding, also, increased applications as a bleaching agent and for the purification of drinking water, as well as for the manufacture of various chlorination products.

Its great handicap for rapid introduction is again the question of freight, where heavy and expensive containers become indispensable.

In most cases the transportation problem of chlorine is solved more economically by handling it as chloride of lime, which, after all, represents chlorine or oxygen in solid form, easily transportable.

It would seem as if the freight difficulty could easily be eliminated by producing the chlorine right at the spot of consumption. But this is not always so simple as it may appear. To begin with, the cost of an efficient plant for any electrolytic operation is always unusually high as compared to other chemical equipments. Then, also, small electrolytic alkali plants are not profitable to operate. Furthermore, the conditions for producing cheap chlorine depend on many different factors, which all have to coordinate advantageously; for instance, cheap power, cheap fuel and cheap raw materials are essential, while, at the same time, a profitable outlet must be found for the caustic soda.

Lately, there has been a considerable reduction of the market price of caustic soda; all this may have for effect that the less efficient electrolytic processes will gradually be eliminated; although this may not necessarily be the case for smaller plants which do not compete in the open market, but consume their own output for some special purpose.

Several distinct types of electrolytic cells are now in successful use, but experience seems to demonstrate that the so-called diaphragm cells are cheapest to construct and to operate, provided, however, no exception be taken to the fact that the caustic soda obtained from diaphragm cells always contains some sodium chloride, usually varying from two to three per cent., which it is not practical to eliminate, but which for almost all purposes does not interfere in the least with its commercial use.

Mercury cells give a much purer caustic soda, and this may, in some cases, compen-

sate for their more expensive equipment and operation. Moreover, there are some purposes where the initial caustic solution of rather high concentration, produced directly in these cells, can be used as it is without further treatment, thus obviating further concentration and cost of fuel.

The expenses for evaporation and elimination of salt from the raw caustic solutions increase to an exaggerated extent with some types of diaphragm cells, which produce only very weak caustic liquors. This is also the case with the so-called "gravity cell," sometimes called the "bell type," or "Aussig type," of cell. But these gravity cells have the merit of dispensing with the delicate and expensive problem of diaphragms. On the other hand, their units are very small, and, on this account, they necessitate a rather complicated installation, occupying an unusually large floor space and expensive buildings.

The general tendency is now toward cells which can be used in very large units, which can be housed economically, and of which the general cost of maintenance and renewal is small; some of the modern types of diaphragm cells are now successfully operating with 3,000 to 5,000 amperes per cell.

As to the possible future improvements in electrolytic alkali cells, we should mention that in some types the current efficiencies have practically reached their maximum, and average ampere efficiencies as high as 95 to 97 per cent. have been obtained in continuous practise. The main difficulty is to reinforce these favorable results by the use of lower voltage, without making the units unnecessarily bulky, or expensive in construction, or in maintenance, all factors which soon outweigh any intended saving of electric current.

Here, more than in any other branch of chemical engineering, it is easy enough to determine how "good" a cell is on a limited trial, but it takes expensive, long continuous use on a full commercial scale, running uninterruptedly day and night for years, to find out how "bad" it is for real commercial practise.

In relation to the electrolytic alkali industry, a great mistake is frequently committed by considering the question of power as paramount; true enough, cheap power is very important, almost essential, but certainly it is not everything. There have been cases where it was found much cheaper in the end to pay almost double for electric current in a certain locality, than in another site not far distant from the first, for the simple reason that the cheaper power supply was hampered by frequent interruptions and expensive disturbances, which more than offset any possible saving in cost of power.

In further corroboration, it is well known that some of the most successful electrolytic soda manufacturers have found it to their advantage to sacrifice power by running their cells at decidedly higher voltage than is strictly necessary—which simply means consuming more power—and this in order to be able to use higher current densities, thereby increasing considerably the output of the same size units, and thus economizing on the general cost of plant operation. Here is one of the ever recurring instances in chemical manufacturing where it becomes more advantageous to sacrifice apparent theoretical efficiency in favor of industrial expediency.

All this does not diminish the fact that the larger electrochemical industries can only thrive where cheap power is available.

Modern progress of electrical engineering has given us the means to utilize so-called natural powers; until now, however, we have only availed ourselves of the water-power developed from rivers, lakes

and waterfalls. As far as large electric power generation is concerned, the use of the wind, or the tide, or the heat of the sun, represents, up till now, nothing much beyond a mere hope of future possibilities.

In the meantime, it so happens, unfortunately, that many of the most abundant water-powers of the world are situated in places of difficult access, far removed from the zone of possible utilization.

But, precisely on this account, it would appear, at first sight, as if the United States, with some of her big water-powers situated nearer to active centers of consumption, would be in an exceptionally favorable condition for the development of electrochemical industries. On closer examination, we find, however, that the cost of water-power, as sold to manufacturers, is, in general, much higher than might be expected; at any rate, it is considerably more expensive than the cost of electric power utilized in the Norway nitrate enterprises.

This is principally due to the fact that in the United States, water-power, before it is utilized by the electrolytic manufacturer, has already to pay one, two and sometimes three, profits, to as many intermediate interests, which act as so many middlemen between the original water-power and the consumer. Only in such instances as in Norway, where the electrochemical enterprise and the development of the water-power are practically in the same hands, can electric current be calculated at its real cheapest cost.

Neither should the fact be overlooked that the best of our water-powers in the east are situated rather far inland. Although this does not matter much for the home market, it puts us at a decided disadvantage for the exportation of manufactured goods, in comparison again with Norway, where the electrolytic plants are situated quite close to a good sea-harbor open in all seasons.

Some electrochemical enterprises require cheap fuel just as much as cheap power; and, on this account, it has proved sometimes more advantageous to dispense entirely with water-power by generating gas for fuel as well as for power from cheap coal or still cheaper peat.

At present most of our ways of using coal are still cumbersome and wasteful, although several efficient methods have been developed which some day will probably be used almost exclusively, principally in such places where lower grades of cheap coal are obtainable.

I refer here particularly to the valuable pioneer work of that great industrial chemist, Mond, on cheap water-gas production, by the use of limited amount of air in conjunction with water vapor.

More recently, this process has been extended by Caro, Frank and others, to the direct conversion of undried peat into fuel-gas.

By the use of these processes, peat or lower grades of coal, totally unsuitable for other purposes, containing, in some instances, as much as 60 to 70 per cent. of incombustible constituents, can be used to good advantage in the production of fuel for power generation.

Whether Mond-gas will ever be found advantageous for distribution to long distances, is questionable, because its heating value per cubic foot is rather less than that of ordinary water-gas, but this does not interfere with its efficient use in internal combustion engines.

In general, our methods for producing or utilizing gas in our cities do scant justice to the extended opportunities indicated by our newer knowledge.

Good fuel-gas could be manufactured and distributed to the individual household

consumer at considerably cheaper rates, if it were not for antiquated municipal specifications, which keep on prescribing photometric tests instead of insisting on standards of fuel value, which makes the cost of production unnecessarily high, and disregards the fact that for lighting, the Welsbach mantle has rendered obsolete the use of highly carbureted gas as a bare flame. But for those unfortunate specifications, cheap fuel-gas might be produced at some advantageous central point, where very cheap coal is available; such heating gas could be distributed to every house and every factory, where it could be used cleanly and advantageously, like natural gas, doing away at once with the black coal smoke nuisance, which now practically compels a city like New York to use nothing but the more expensive grades of anthracite coal. It would eliminate, at the same time, all the bother and expense caused through the clumsy and expensive methods of transportation and handling of coal and ashes; it would relieve us from many unnecessary middlemen which now exist between coal and its final consumer.

The newer large-sized internal combustion engines are introducing increasing opportunities for new centers of power production where waste gas of blast-furnaces or coke-ovens, or where deposits of inferior coal or peat, are available.

If such centers are situated near tidewater, this may render them still more advantageous for some electrochemical industries, which, until now, were compelled to locate near some inland waterpowers.

Nor should we overlook the fact that the newer methods for the production of cheap fuel-gas offer excellent opportunities for an increased production of valuable tar by-products, and more particularly of ammonium salts; the latter would help to a not inconsiderable extent in furnishing more nitrogen fertilizer.

It is somewhat remarkable that a greater effort has already been made to start the industrial synthesis of nitrogen products than to economize all these hitherto wasted sources of ammonia.

In fact, science indicates still other ways, somewhat of a more radical nature, for correcting the nitrogen deficiencies in relation to our food supply.

Indeed, if we will look at this matter from a much broader standpoint, we may find that, after all, the shortage of nitrogen in the world is attributable to a large extent to our rather one-sided system of agriculture. We do not sufficiently take advantage of the fact that certain plants, for instance those of the group of Leguminosæ, have the valuable property of easily assimilating nitrogen from the air, without the necessity of nitrogen fertilizers. In this way, the culture of certain Leguminosæ can insure enough nitrogen for the soil, so that, in rotation with nitrogen consuming crops, like wheat, we could dispense with the necessity of supplying any artificial nitrogen fertilizers.

The present nitrogen deficiency is influenced further by two other causes:

The first cause is our unnecessary exaggerated meat diet, in which we try to find our proteid requirements, and which compels us to raise so many cattle, while the amount of land which feeds one head of cattle could furnish, if properly cultivated, abundant vegetable food for a family of five.

The second cause is our insufficient knowledge of the way to grow and prepare for human food just those vegetables which are richest in proteids. Unfortunately, it so happens that exactly such plants as, for instance, the soy-bean are not by any means easily rendered palatable and digestible;

while any savage can eat raw meat, or can readily cook, boil or roast it for consumption.

On this subject, we can learn much from some Eastern people, like the Japanese, who have become experts in the art of preparing a variety of agreeable food products from that refractory soy-bean, which contains such an astonishingly large amount of nutritious proteids, and which, long ago, became for Japan a wholesome, staple article of diet.

But, on this subject, the Western races have not yet progressed much beyond the point of preparing cattle-feed and paint oil from the soy-bean, although the more extended culture of this, or similar plants, might work about a revolution in our agricultural economics.

Agriculture, after all, is nothing but a very important branch of industrial chemistry, although most people seem to ignore the fact that the whole prosperity of agriculture is based on the success of that photochemical reaction which, under the influence of the light of the sun, causes the carbon dioxide of the air to be assimilated by the chlorophyl of the plant.

It is not impossible that photochemistry, which hitherto has busied itself almost exclusively within the narrow limits of the art of making photographic images, will, some day, attain a development of usefulness at least as important as all other branches of physical chemistry. In this broader sense, photochemistry seems an inviting subject for the agricultural chemist. The possible rewards in store in this almost virgin field may, in their turn, by that effect of superinduction between industry and science, bring about a rapid development similar to what we have witnessed in the advancement of electricity, as well as chemistry, which both began to progress by bounds and leaps, way ahead of other sciences, as soon as their growing industrial applications put a high premium on further research.

Photochemistry may allow us some day to obtain chemical effects hitherto undreamed of. In general, the action of light in chemical reactions seems incomparably less brutal than all means used heretofore in chemistry. This is the probable secret of the subtle chemical syntheses which happen in plant life. To try to duplicate these delicate reactions of nature by our present methods of high temperatures, electrolysis, strong chemicals and other similar torture-processes, seems like trying to imitate a masterpiece of Gounod by exploding a dynamite cartridge between the strings of a piano.

But there are endless other directions for scientific research, relating to industrial applications, which, until now, do not seem to have received sufficient attention.

For instance, from a chemical standpoint, the richest chemical enterprise of the United States, the petroleum industry, has hitherto chiefly busied itself with a rather primitive treatment of this valuable raw material, and little or no attention has been paid to any methods for transforming at least a part of these hydrocarbons into more ennobled products of commerce than mere fuel or illuminants.

A hint as to the enormous possibilities which may be in store in that direction is suggested by the recent work in Germany and England on synthetic rubber; the only factor which prevents extending the laboratory synthesis of rubber into an immense industrial undertaking is that we have not yet learned how to make cheaply the isoprene or other similar non-saturated hydrocarbons which are the starting point in the process which changes their molecules, by polymerization, into rubber.

Nor has our science begun to find the

best uses for such inexpensive and never exhaustible vegetable products as cellulose or starch. Quite true, several important manufactures, like that of paper nitrocellulose, glucose, alcohol, vinegar and some others, have been built on it; but to the chemist at least, it seems as if a much greater development is possible in the cheaper and more extended production of artificial fiber. Although we have succeeded in making so-called artificial silk, this article is still very expensive; furthermore, we have not yet produced a cheap, good, artificial fiber of the quality of wool.

If we have made ourselves independent of Chile for our nitrogen supply, we are still absolutely at the mercy of the Stassfurt mines in Germany for our requirements of soluble potash-salts, which are just as necessary for agriculture. Shall we succeed in utilizing some of the proposed methods for converting that abundant supply of feldspar, or other insoluble potash-bearing rocks, into soluble potash-salts by combining the expensive heat treatment with the production of another material like cement, which would render the cost of fuel less exorbitant? Or shall the problem be solved in setting free soluble potassium salts as a by-product in a reaction engendering other staple products consumed in large quantities?

We have several astonishingly conflicting theories about the constitution of the center of the globe, but we have not yet developed the means to penetrate the world's crust beyond some deep mines—merely an imperceptible faint scratch on the surface—and in the meantime, we keep on guessing, while to-day astronomers know already more about the surface of the planet Mars than we know about the interior of the globe on which we live.

Nor have we learned to develop or utilize the tremendous pressures under which most minerals have been formed, and still less do we possess the means to try these pressures, in conjunction with intensely high temperatures.

No end of work is in store for the research chemist, as well as for the chemical engineer, who can think by himself, without always following the beaten track. We are only at the beginning of our successes, and yet, when we stop to look back to see what has been accomplished during the last generations, that big jump from the rule-of-thumb to applied science is nothing short of marvelous.

Whoever is acquainted with the condition of human thought to-day must find it strange, after all, that scarcely seventy years ago, Mayer met with derision even amongst the scientists of the time, when he announced to the world that simple but fundamental principle of the conservation of energy.

We can hardly conceive that just about the time the Columbia School of Mines was founded, Liebig was still ridiculing Pasteur's ideas on the intervention of micro-organisms in fermentation, which have proved so fecund in the most epoch-making applications in science, medicine, surgery and sanitation, as well as in many industries.

Fortunately, true science, contrary to other human avocations, recognizes nobody as an "authority," and is willing to change her beliefs as often as better studied facts warrant it; this difference has been the most vital cause of her never ceasing progress.

To the younger generation, surrounded with research laboratories everywhere, it may cause astonishment to learn that scarcely fifty years ago, that great benefactor of humanity, Pasteur, was still repeating his pathetic pleadings with the French government to give him more suita-

ble quarters than a damp, poorly lighted basement, in which he was compelled to carry on his research; and this was, then, the condition of affairs of no less a place than Paris, the same Paris that was spending, just at that time, endless millions for the building of her new Opera-Palace.

Such facts should not be overlooked by those who might think that America has been too slow in fostering chemical research.

If the United States has not participated as early as some European countries in the development of industrial chemistry, this was chiefly because conditions here were so totally different from those of nations like Germany, England and France, that they did not warrant any such premature efforts.

In a country so full of primary resources, agriculture, forests, mines and the more elementary industries directly connected therewith, as well as the problems of transportation, appealed more urgently to American intellectual men of enterprise.

Why should anybody here have tried to introduce new, difficult or risky chemical industries, when on every side, more urgently important fields of enterprise were inviting all men of initiative?

Chemical industries develop along the lines furnished by the most immediate needs of a country. Our sulphuric acid industry, which can boast to-day of a yearly production of about three million tons, had to begin in an exceedingly humble way, and the first small amounts of sulphuric acid manufactured here found a very scant outlet.

It required the growth of such fields of application as petroleum refining, superphosphates, explosives and others, before the sulphuric acid industry could grow to what it is to-day.

At present, similar influences are still dominating our chemical industries; they are generally directed to the mass production of partly manufactured articles. This allows us to export, at present, to Germany, chemicals in crude form, but in greater value than the total sum of all the chemical products we are importing from her; although it can not be denied that a considerable part of our imports are products like alizarine, indigo, aniline dyes and similar synthetic products which require higher chemical manufacturing skill.

In this connection, it may be pointed out that our exports of oleomargarine, to Germany alone, are about equivalent to our imports of aniline dyes.

But all this does not alter the fact that in several important chemical industries, the United States has been a pioneer. Such flourishing enterprises as that of the artificial abrasives, carborundum and alundum, calcium carbide, aluminum and many others, testify how soon we have learned to avail ourselves of some of our water-power.

One of the most important chemical industries of the world, the sulphite cellulose industry, of which the total annual production amounts to three and a half million tons, was originated and developed by a chemist in Philadelphia, B. C. Tilgman. But its further development was stopped for awhile on account of the same old trouble, lack of funds, after $40,000 were spent, until some years later, it was taken up again in Europe and reintroduced in the United States, where it has developed to an annual production of over a million tons.

What has been accomplished in America in chemical enterprises, and what is going on now in industrial research, has been brilliantly set forth by Mr. Arthur D. Little.[2]

Nor at any time in the history of the

2 *Journal of Ind. and Eng. Chem.*, Vol. 5, No. 10, October, 1913.

United States was chemistry neglected in this country; this has recently been brought to light in the most convincing manner by Professor Edgar F. Smith of Philadelphia.[3]

The altruistic fervor of that little group of earlier American chemists, who, in 1792, founded the Chemical Society of Philadelphia (probably the very first chemical society in the world), and in 1811, the Columbia Chemical Society of Philadelphia, is best illustrated by an extract of one of the addresses read at their meeting in 1798:

> The only true basis on which the independence of our country can rest are agriculture and manufactures. To the promotion of these nothing tends in a higher degree than chemistry. It is this science which teaches man how to correct the bad qualities of the land he cultivates by a proper application of the various species of manure, and it is by means of a knowledge of this science that he is enabled to pursue the metals through the various forms they put on in the earth, separate them from substances which render them useless, and at length manufacture them into the various forms for use and ornament in which we see them. If such are the effects of chemistry, how much should the wish for its promotion be excited in the breast of every American! It is to a general diffusion of knowledge of this science, next to the virtue of our countrymen, that we are to look for the firm establishment of our independence. And may your endeavors, gentlemen, in this cause, entitle you to the gratitude of your fellow-citizens.

This early scientific spirit has been kept alive throughout the following century by such American chemists as Robert Hare, E. N. Horsford, Wolcott Gibbs, Sterry Hunt, Lawrence Smith, Carey Lea, Josiah P. Cooke, John W. Draper, Willard Gibbs and many others still living.

Present conditions in America can be measured by the fact that the American Chemical Society alone has over seven thousand members, and the Chemists' Club of New York has more than a thousand members, without counting the more specialized chemical organizations, equally active, like the American Institute of Chemical Engineers, the American Electrochemical Society and many others.

During the later years, chemical research is going on with increasing vigor, more especially in relation to chemical problems presented by enterprises which at first sight seem rather remote from the so-called chemical industry.

But the most striking symptom of newer times is that some wealthy men of America are rivaling each other in the endowment of scientific research on a scale never undertaken before, and that the scientific departments of our government are enlarging their scope of usefulness at a rapid rate.

But we are merely at the threshold of that new era where we shall learn better to use exact knowledge and efficiency to bring greater happiness and broader opportunities to all.

However imposing may appear the institutions founded by the Nobels, the Solvays, the Monds, the Carnegies, the Rockefellers and others, each of them is only a puny effort to what is bound to come when governments will do their full share. Fancy that if, for instance, the Rockefeller Institute is spending to good advantage about half a million dollars per annum for medical research, the chewing-gum bill of the United States alone would easily support half a dozen Rockefeller Institutes; and what a mere insignificant little trickle all these research funds amount to, if we have the courage to compare them to that powerful gushing stream of money which yearly drains the war budget of all nations.

In the meantime, the man of science is patient and continues his work steadily, if somewhat slowly, with the means hitherto at his disposal. His patience is inspired by the thought that he is not working for

[3] "Chemistry in America," published by D. Appleton & Co. New York and London, 1914.

to-day, but for to-morrow. He is well aware that he is still surrounded by too many "men of yesterday," who delay the results of his work.

Sometimes, however, he may feel discouraged that the very efficiency he has succeeded in reaching at the cost of so many painstaking efforts, in the economical production of such an article of endlessly possible uses, as Portland Cement, is hopelessly lost many times over and over again, by the inefficiency, waste and graft of middlemen and political contractors, by the time it gets on our public roads, or in our public buildings. Sometimes the chaos of ignorant brutal waste which surrounds him everywhere may try his patience. Then again, he has a vision that he is planting a tree which will blossom for his children and will bear fruit for his grandchildren.

In the meantime, industrial chemistry, like all other applications of science, has gradually called into the world an increasing number of men of newer tendencies, men who bear in mind the future rather than the past, who have acquired the habit of thinking by well-established facts, instead of by words, of aiming at efficiency instead of striking haphazard at ill-defined purposes. Our various engineering schools, our universities, are turning them out in ever increasing numbers, and better and better prepared for their work. Their very training has fitted them out to become the most broad-minded progressive citizens.

However, their sphere of action, until now, seldom goes beyond that of private technical enterprises for private gain. And yet, there is not a chemist, not an engineer, worthy of the name, who would not prefer efficient, honorable public service, freed from party politics, to a mere money-making job.

But most governments of the world have been run for so long almost exclusively by lawyer-politicians, that we have come to consider this as an unavoidable evil, until sometimes a large experiment of government by engineers, like the Panama Canal, opens our eyes to the fact that, after all, successful government is—first and last—a matter of efficiency, according to the principles of applied science.

Was it not one of our very earliest American chemists, Benjamin Thompson, of Massachusetts, later knighted in Europe as Count Rumford, who put in shape the rather entangled administration of Bavaria by introducing scientific methods of government?

Pasteur was right when one day exasperated by the politicians who were running his beloved France to ruin, he exclaimed:

> In our century, science is the soul of the prosperity of nations and the living source of all progress. Undoubtedly, the tiring daily discussions of politics seem to be our guide. Empty appearances! What really leads us forward are a few scientific discoveries and their applications.

PRELIMINARY REPORT ON THE DISCOVERY OF HUMAN REMAINS IN AN ASPHALT DEPOSIT AT RANCHO LA BREA[1]

Introduction

In January, 1914, the Museum of History, Science and Art of Los Angeles, being inconvenienced by heavy rains filling the pits already in process of excavation in the asphalt deposits at Rancho La Brea, began work at a new locality, which was designated as pit number ten. Work was started at a point a short distance southwest of a large pit from which many remains of extinct animals had been obtained in previous years. The point at which excavation was initiated was marked by a seepage from which tar had poured out in comparatively recent time. The excavation of this locality showed the presence of two vents

[1] Read at the Museum of History, Science and Art, Los Angeles, California, June 11, 1914.

or chimneys filled with asphalt. The chimneys were each about three feet in diameter and both had contributed to a hard asphaltic layer forming the surface of the ground at this point. At a depth of about eight feet the chimneys opened into a large dome-shaped asphaltic mass not less than eight feet in diameter and extending downward to an unknown depth.

Remains of many kinds of animals were obtained in both chimneys, but the most interesting discovery was the finding on February 5 of an upper jaw from a human skull, at a depth of a little more than six feet, in the northerly of the two chimneys. Careful investigation of this vent disclosed later almost the entire skull with other portions of the skeleton. The remains evidently belonged to one individual. The bones were found ranging in depth down to a level of about nine feet below the surface, and reaching almost to the point at which the chimney connected with the dome-like reservoir below.

Realizing that this find might prove of exceptional scientific interest, unusual precautions were taken in the excavations following the discovery of the human remains. Under the direction of Mr. Frank S. Daggett, director of the Museum, and of Mr. L. E. Wyman, who had immediate charge of the work in the pits, the excavators obtained all possible information as to the nature of the deposit in which the specimen was found, and every bone appearing in the deposit was saved. The final results of the work give us a complete map of the deposit, and full list of the animal remains from the two chimneys, with their situation in the chimneys.

Through the courtesy of Mr. Frank S. Daggett, director of the Museum of History, Science and Art, it has been the writer's privilege to follow closely the course of the excavations in the pit in which the human remains were found, and to make a study of this most interesting occurrence. Most efficient assistance has been given in every possible way by Mr. Daggett, by Mr. Wyman, and by every one connected with the work. The handling of the excavation by the museum staff, and the careful exercise of precautions necessary to insure the scientific accuracy of the work, are worthy of most favorable comment.

Character of the Problem

As a part of the general problem of the history of the human family, involving questions of the origin and of the true nature of man, the history of the human race in America has interested every thoughtful person. The occurrence of human remains at Rancho La Brea, appearing as it has in close relation to a marvelous representation of life from a past period, has justly demanded attention.

The interest in the human skeleton from Rancho La Brea centers either on peculiarities in the character of the skeleton itself, or in evidences of its antiquity furnished by definite indications of the geologic age of the deposits in which it was found or through proof of age presented by the animals associated with the skeleton.

Nature and Origin of the Deposits Containing Human Remains

Purely geologic evidences of age are often exceedingly difficult to obtain in asphalt deposits, owing to the peculiar mode of accumulation, and the possibility of movement in the deposits after they are once formed. The asphalt is a residue from evaporation of oil. It accumulates either on the surface of the ground or in the midst of other strata into which it has soaked or poured. Even after the asphalt deposit has formed, the nature of the viscous material makes possible considerable movement in many directions within the mass, and consequent change of position of any materials in it.

The deposits in which fossil remains have been found at Rancho La Brea are evidently in part layers formed on the surface, and in part pipes, pockets and chimneys through which oil came up from deeply buried strata. The source of the asphalt or oil is a deep-lying formation, which is considerably folded, and is covered by approximately horizontal layers of clayey and sandy strata washed in from higher land not far away. Oil and gas have

been seeping through the superficial horizontal deposit for a very long period, and have formed more or less definite channels or pipes along lines of least resistance. In some cases these pipes have evidently enlarged themselves locally to chimneys several feet in diameter.

At pit number ten, in which the human remains were discovered, the asphalt deposit consists of two pipes or chimneys connecting with surface flows above. The chimneys arise below from a large dome-shaped asphaltic reservoir. This dome may be an old surface pool now buried and forming a part of the passageway for further upward movement of oil; or it may be an enlargement of a chimney that was originally very much smaller.

The asphalt in the chimneys and in the dome in pit ten was largely a soft, viscous mass containing a high percentage of sand, and including in some regions many angular lumps of hard, weathered asphalt. The contents of the chimneys are entirely unlike the surrounding soil or rock. The material through which the chimneys pass is not homogeneous, but is composed of approximately horizontal strata of clay, sand and gravel, with a small inclusion of asphaltic material in most places. The contact between the chimneys and the matrix through which they pass was everywhere sharply marked.

The sand content of the asphalt in the chimneys and in the reservoir below is quite uniform in grain and in distribution through the mass. The sand may have been mingled with the tar by entrance through the upper end of the chimneys or may have been carried up from below. The available evidence favors the view that it came from the sandy layers from which the oil is seeping upward, or through which the oil passes on the way.

The lumps of hard asphalt embedded in the soft sandy matrix in one chimney are generally of irregular form, and may be much oxidized or weathered. They were evidently derived from asphalt masses that were oxidized by exposure to the weather for a considerable time. They are not found in the dome below and evidently came into the chimney from above.

The chimneys in pit ten may have originated through gradual building up of the walls around open pipes connected with the oil-supply below. They may have developed as channels forced through deposits already formed. Regardless of the mode of origin, the chimneys have certainly been passage-ways through which asphaltic materials have moved sometimes up and sometimes down for a period of unknown extent. It is not improbable that at one time these pipes were longer than at present, the surface of the ground being at a relatively higher level. Erosion may have carried away many feet of deposits at this point, shortening the chimneys much below their length at an earlier time. If the history of these chimneys is like that of some now open in this region, they may have spilled their contents widely at times, and on other occasions, the tar may have receded, so as to leave long empty tubes or chambers. If such a period of recession lasted any great length of time, one would expect the tar around the opening above and adhering to the walls of the tube to be much weathered.

In various ways, dry, oxidized pieces might be broken off around the vent and accumulate as angular fragments below. A later rising of the tar would give a mixture of tar, sand and weathered lumps. If the whole chimney stagnated and oxidized for a time, a later outbreak of oil or asphalt following along the side of the old channel would give two parallel pipes filled with somewhat different materials.

As nearly as one can judge from observations available, the north chimney had a varied history presenting stages like most of those discussed as possibilities. The south chimney, containing only soft, sandy asphalt, evidently had a more uniform history or a shorter history.

Remains of Animals Found in the Pit Containing Human Remains

Bones of birds and mammals were abundant in both chimneys. In the south chimney, which is wide above and narrows sharply below, large bones are found only above the nar-

rowing of the pipe. In the large reservoir below the chimneys only small bones appear, and these were found only in a limited space near the point of union of the lower reservoir and the two chimneys. The distribution of bones shows conclusively that they came from above, and were not carried up from the depths with ascending oil.

The total number of specimens found in the chimneys was large, and will aggregate several thousand. These bones represent a considerable variety of mammals and birds. They include bear, coyote, a wolf of the timber-wolf type, skunk, weasel, horse, antelope, rabbit, pocket-gophers, field-mice, eagles, owls, vultures, crows, and many other forms.

The fauna from the two chimneys in pit ten is in general like that of California at the present time. It differs greatly from that of the pits in which the well-known Rancho La Brea fauna is found through the absence of the great wolf, saber-tooth, sloth, small antelope, camel, and many other mammals and birds abundantly represented in the typical Rancho La Brea deposits.

The only extinct form certainly recognized in the material from the two chimneys is *Teratornis,* a gigantic condor-like bird, as yet known only from Rancho La Brea, and recognized by Dr. L. H. Miller in this collection. Bones of this bird were found in a narrow portion of the north chimney at a depth of about four feet, and considerably above some of the human remains. As nearly as one can judge from the evidence at hand, there seems a reasonable chance that the giant *Teratornis* was a contemporary of the human being whose remains appear in the north chimney of pit ten. The evidence does not present clear proof in favor of this view, but appears to balance in that direction.

The extinct California peacock and two other extinct species are doubtfully reported from the north chimney, but there is doubt as to their having been introduced in the same manner as the other bones making up the fauna.

A small collection found near the upper end of the north chimney contains a number of birds, which, according to Dr. Miller, are quite different from those certainly known from the two chimneys. The matrix in which this small collection was found is also different from that in the chimneys. It seems probable that these specimens really represent an older fauna embedded in a relatively ancient deposit through or near which the north chimney passed.

A portion of the lower jaw of a young horse found at a depth of about five feet and near the *Teratornis* in the north chimney is more slender than any lower jaw of the common extinct horse found in the typical Rancho La Brea fauna. The writer has not, however, compared it with fossil specimens of exactly the same individual stage of development. In slenderness it approaches more closely the jaw of the existing domestic horse. The space between the back teeth and front teeth seems shorter than that in the domestic horse, and is of nearly the same length as in the extinct species from Rancho La Brea. A more careful study of immature specimens from Rancho La Brea in comparison with very young modern horses will be necessary before one can speak authoritatively with reference to the specific determination of this specimen. It will be very interesting to know whether this is an extinct species which lived in California until a comparatively recent time and was contemporaneous with man, but became extinct before this country was visited by white men. The alternative hypothesis is that it represents the colt of a modern horse which fell into the pit within the last century and a half.

The fact that the fauna from the two chimneys is nearly or quite identical with that of the present day, while the typical Rancho La Brea fauna differs greatly and shows close resemblance to the life of the earth at a remote time, makes it evident that the fauna represented in the chimneys of pit ten pertains to a period much later than that in which the typical Rancho La Brea animals lived. The collection from the chimneys represents a time so close to the present that the types of life were nearly the same as those in the region at

the present day. The giant *Teratornis,* and possibly several other extinct forms in this fauna, may indicate that the asphalt in these chimneys was trapping animals at a time removed by some thousands of years from the present. On the other hand, it may be that these species were living here within historic time. A third possibility is that the bones of such extinct species as are found here have been removed in some way from an older deposit, and found a resting place in the chimneys in comparatively recent time. Still more remote is a fourth possibility that in Pleistocene time these chimneys connected with an open pool far above the present surface of the ground; that bones of a few animals trapped at that time sank to the position in which they were found in the excavations; and that after the removal of the upper deposits by erosion, the later or younger fauna was trapped and mingled with the few bones of earlier date.

The Human Remains

The human bones were all found in the north chimney, where the history of accumulation is more complicated than in the south vent. The pit containing the human remains also contains all of the presumably associated specimens representing extinct animals.

The human remains were found rather widely scattered between a depth of about six feet and nine feet. The whole collection of human bones seems to represent one individual. The bones are generally very much worn. The wear in some cases suggests movement within the pit in such a manner that sand in the tar, or resting against the wall of the chimney, has cut away the bone by long-continued rubbing.

Enough of the human skeleton was found in the pit to give a fairly satisfactory idea as to the characteristics of the individual it represents. The skull is that of a small person of middle age, possibly a woman. The brain case is relatively as large as that in some of the living native races of America. According to Dr. A. L. Kroeber the racial characteristics do not differ decidedly from those of people whose remains have been excavated in mounds on Santa Rosa Island off the coast of southern California. So far as the characteristics of the skeleton are concerned, it is not necessary to suppose that we have here an individual who lived at a remote time when the human family was in a relatively low stage of evolution. This skull is not comparable to those of ancient races of the Neanderthal or earlier types. On the other hand, one must not forget that people of a fairly advanced stage of brain development were already in existence at the beginning of the present or Recent geological period.

The characters of the human remains taken by themselves indicate that this person lived either within the present or Recent period, or at a time not earlier than the end of the Pleistocene period immediately preceding it.

Conclusions

A summary of available information regarding the age of the human skeleton found in pit ten at Rancho La Brea is as follows:

1. The evidence of geologic occurrence in the asphalt chimney taken by itself counts for relatively little owing to the peculiar conditions under which these deposits are formed. In so far as this is of value it suggests an age later than that of the tar pits containing the typical Rancho La Brea fauna.

2. The fauna associated with the human remains in pit ten is quite different from the typical Pleistocene Rancho La Brea fauna, and must have inhabited this region at a different period. The fauna in pit ten is closely related to that of the present or Recent period. It is distinctly later in age than the typical Rancho La Brea fauna.

3. The characters of the human remains, taken by themselves, show a stage of development similar to that of man of the present day and not earlier than man of the latest Pleistocene time.

4. The evidence as a whole indicates that the human skeleton from pit ten is of a period much later than that of the typical Rancho La Brea fauna, the time being either within the Recent period or not earlier than the very latest portion of Pleistocene time. The possible association of the human remains with

extinct forms, such as the giant *Teratornis*, may indicate some antiquity for the human being, or may indicate comparatively late persistence of birds or mammals now extinct in this region.

5. Measured in terms of years, it is not possible to give a definite estimate of the age of the skeleton from pit ten. It may suffice to state that this person did not live in the period of the low-browed, Neanderthal, Pleistocene man of Europe. It belongs to the distinctly modern stage of evolution. It does not necessarily belong to the present historic period, but can not be considered as having antedated it by many thousands of years. The age of this specimen may perhaps be measured in thousands of years, but probably not in tens of thousands.

6. The study of the remains at pit ten is a problem similar to that presented by the occurrence of an arrowhead found in a comparatively recent asphalt deposit encountered in the University of California excavations of 1912. The arrowhead was found embedded in a deposit somewhat similar to that in pit ten, and the fauna associated with it was in general of Recent aspect.

7. The final summing up of all evidence relative to the antiquity of the Rancho La Brea skeleton will depend on a very detailed and exhaustive study of the typical Pleistocene Rancho La Brea fauna, of the fauna from the later tar deposits like that of pit ten, and of the existing fauna of California. No one of these three factors is, as yet, satisfactorily known. Until they are all known, the last word on this subject can not be written. The significance of this statement may seem larger when reinforced by the remark that the skeletons of a large percentage of our living species have never yet been carefully studied in the way in which this work must be done for use in investigations such as those concerned in this problem.

From whatever point of view this specimen is considered, it is well worth exhaustive scientific investigation.

John C. Merriam

University of California,

June 11, 1914

THE 72-INCH REFLECTING TELESCOPE FOR CANADA

Some eight months ago the Canadian government entered into contracts for the construction of a 72-inch reflecting telescope, with the J. A. Brashear Company for the optical parts and the Warner and Swasey Company for the mounting. This telescope, which will be considerably larger than any in use, will be of the most modern type and will be used principally in the determination of stellar radial velocities. The progressive policy of the Canadian government in the encouragement of scientific research, as evidenced by the order for this magnificent instrument has now been rendered doubly effective by authorizing at a very considerable additional expense, the total outlay being upward of $200,000, its installation in the best astronomical location in the dominion.

Investigations have been in progress for upwards of a year at five places, representative of different climatic conditions in the country. The region around Victoria, B. C., so much excelled all the others, including Ottawa, in the two most important particulars, the "seeing" or steadiness and quality of definition, and the small daily temperature variation, while being at least equal in other qualifications, that it was strongly recommended to the government by the chief astronomer as the site for the telescope. The government of the province of British Columbia, on being approached for help towards the additional cost of location away from Ottawa, generously contributed $10,000 for the purchase of the necessary land and agreed to build a road, which will cost about $20,000, to the chosen site which is at the summit of Saanich Hill, altitude 732 feet, about eight miles north of Victoria.

Immediately on the decision of the dominion government in favor of this site, fifty acres of land were purchased around the summit of the hill, and arrangements were concluded for the construction of the road this fall. This road will be upwards of a mile and a half in length, leading from the main road and the electric railway at the foot of the hill by a 7 per cent. grade to the summit.

Building operations will begin early in 1915 and the dome should be ready for the telescope in the fall of that year. Word has been received that the 72-inch disc for the mirror has been successfully cast and annealed at St. Gobain, and work on its grinding and polishing will shortly be commenced. The design of the mounting, which has many new features, and will undoubtedly be better and more convenient in operation than any hitherto made, is practically completed and construction work on the heavy steel castings required has been begun. It is hoped, therefore, that the telescope will be mounted and ready for operation by the end of next year.

SCIENTIFIC NOTES AND NEWS

A replica of the bust of Louis Pasteur by Dubois has been presented to the American Museum of Natural History for installation in the hall of public health, through the generosity of Dr. Roux, director of the Pasteur Institute in Paris and M. Vallery-Radot, son-in-law of M. Pasteur.

Dr. Charles W. Eliot, president emeritus of Harvard University, has been elected a corresponding fellow of the British Academy.

The Canadian government has appointed Mr. James White to be assistant chairman of the Commission of Conservation, and Dr. C. Gordon Hewitt, dominion entomologist, to be Canadian representative on the permanent committee of the "International Conference for the Global Protection of Nature."

Mr. James Barnes, of the Barnes-Kearton expedition, which crossed Central Africa under the auspices of the American Museum, has returned to New York, bringing with him a series of motion-picture films. Mr. Barnes will give an exhibition of these films to the members of the museum in the fall.

The Royal Institute of Public Health, in pursuance of the terms of a trust which enables it to award annually a gold medal to a public health medical official, at home or abroad, in recognition of conspicuous services rendered to the cause of preventive medicine within the British empire, has conferred the medal for 1914 upon Mr. James Niven, medical officer of health for Manchester.

We learn from *Nature* that the honorary freedom of Newcastle-on-Tyne was conferred on Hon. Sir C. A. Parsons on July 10 in recognition of his achievements in science, particularly as the inventor of the steam turbine. It had been decided to confer a similar honor on Sir Joseph W. Swan, but he has since died. The symbols of the freedom—a scroll and casket—have, however, been presented to a representative of his family.

Sir John Tweedy, formerly president of the Royal College of Surgeons of England, has been elected president of the Medical Defence Union, in the room of Dr. Edgar Barnes.

V. I. Safro (Cornell, '09), formerly of the U. S. Bureau of Entomology and the Oregon Agricultural College, has been appointed entomologist with the Kentucky Tobacco Product Company, of Louisville, Kentucky.

The following list of members of the Imperial Transantarctic Expedition is given in *Nature*: *Weddell Sea Party*—Sir Ernest H. Shackleton, leader of the expedition; Mr. Frank Wild, second in command; Mr. G. Marston, Mr. T. Crean, Captain Orde Lees, Lieutenant F. Dobbs, Lieutenant Courtney Brocklehurst, Mr. J. Wordie, geologist; Mr. R. W. James, physicist and magnetician; Mr. L. H. Hussey, assistant magnetician and meteorologist; Mr. F. Hurley, photographer and kinematographer; Mr. V. Studd, geologist; Lieutenant F. A. Worsley, in navigating command of the *Endurance* on the voyage from London to Buenos Aires and the Weddell Sea, and afterwards to take part in the surveying and exploring of the coast; Mr. Jeffreys, Mr. Hudson and Mr. A. Cheetham. *Ross Sea Party*—Lieutenant Aeneas Mackintosh, leader and meteorologist; Mr. E. Joyce, zoologist; Mr. H. Ninnis; Mr. H. Wild, and Dr. Macklin, surgeon. There only remain two vacancies, and these are to be filled by another doctor and a biologist. The arrangements for the Ross Sea ship *Aurora* are not yet quite

complete, but the *Endurance*, with the Weddell Sea party, has now sailed.

A bill to extend the thanks of congress to the engineering members of the Isthmian Canal Commission has been reported to the House with a favorable recommendation by the Military Affairs Committee. The men who would receive this honor are Colonel George W. Goethals, General William C. Gorgas, Colonel H. F. Hodges, Lieutenant Colonel William L. Sibert and Civil Engineer H. H. Rousseau. The bill authorizes the president to advance Colonel Goethals and General Gorgas to the rank of Major General, the former of the line and the latter of the medical department. It is provided also that the president may, upon the retirement of Colonel Hodges, Lieutenant Colonel Sibert and Civil Engineer Rousseau, advance each of these officers one grade on the retired list.

Sir Clements Markham has unveiled at Cheltenham a statue of Dr. Edward Adrian Wilson, who was born in that town, and perished with Captain Scott on the great ice barrier in March, 1912. The statue was designed by Lady Scott.

Professor Francis Humphreys Storrer, from 1865 to 1870 professor of chemistry in the Massachusetts Institute of Technology and, from 1870 to his retirement as emeritus professor in 1907, professor of agricultural chemistry at Harvard University, has died at the age of eighty-two years.

The Rev. Horace Carter Hovey, fellow of the Geological Society of America and of the American Association for the Advancement of Science, known especially for his publications on caverns and subterreanean fauna and flora, died at his home at Newburyport, Mass., on August 27, in his eighty-second year.

Dr. Frederic Lawrence Kortright, B.S. (Cornell, '90), Sc.D. (Cornell, '95), instructor in chemistry at Cornell University from 1892 to 1899, and subsequently assistant professor and professor at the University of West Virginia, author of contributions on the rare earths, citric acid, silica and other chemical subjects, died on July 13, at the age of forty-seven years.

Professor Franklin William Hooper, director of the Brooklyn Institute of Arts and Sciences, the author of contributions on algæ and glacial geology, died on August 1 at the age of sixty-three years.

The Rev. Osmond Fisher, at one time tutor of Jesus College, Cambridge, known for his important contributions to geology, died on July 12, at the age of ninety-six years.

The death is announced, in his sixty-sixth year, of Sir Christopher Nixon, ex-president of the Royal College of Physicians of Ireland, and Vice-Chancellor of the National University of Ireland.

Professor Paul Reclus, the distinguished Paris surgeon, died on July 29, in his sixty-eighth year.

The U. S. Civil Service Commission announces an examination for plant physiologist, experienced in plant metabolism, for men only, to fill a vacancy in the Bureau of Plant Industry, Department of Agriculture, at a salary of $3,000 a year. A Ph.D. or D.Sc. degree from a college or university of recognized standing, and at least five years' experience in plant physiology since receiving the bachelor's degree, are prerequisites for consideration for this position. Applicants must have reached their twenty-fifth but not their forty-fifth birthday on the date of examination.

The Royal Agricultural Society of England is offering a medal for a monograph or essay, which has not been previously published, giving evidence of original research in any agricultural subject or any of the cognate agricultural sciences applicable to British farming.

The German Paleontological Society is to hold its annual meeting this year in London at the British Museum of Natural History on September 2 to 5. On September 5 and 6 the members will visit Oxford, and on September

7, Cambridge. The society now has 210 members, of whom 19 are Americans.

The eighty-second annual meeting of the British Medical Association was held at Aberdeen on July 28, 29, 30 and 31, under the presidency of Sir Alexander Ogston. The address in medicine was given by Dr. A. E. Garrod, and that in surgery by Sir John Bland-Sutton. Professor J. Arthur Thomson delivered the popular lecture. Sixteen scientific sections were arranged as follows: Anatomy and physiology; dermatology and syphilology; diseases of children, including orthopædics; electro-therapeutics and radiology; gynæcology and obstetrics; laryngology, rhinology and otology; medical sociology; medicine; naval and military medicine and surgery; neurology and psychological medicine; ophthalmology; pathology and bacteriology; pharmacology; therapeutics and dietetics; state medicine and medical jurisprudence; surgery; tropical medicine.

The selection committee for the Captain Scott Memorial in London has unanimously chosen the design submitted by Mr. Albert H. Hodge. The London *Times* gives the following description of the plan of the Antarctic Monument: "A granite pylon is surmounted by a bronze group representing Courage sustained by Patriotism, spurning Fear, Despair and Death, the figure Courage being crowned by Immortality. Below the group the words 'For King,' 'For Country,' 'For Brotherly Love,' and 'For Knowledge' are inscribed. The front of the pylon bears the names of the five heroes, whose portrait medallions in bronze occupy the most prominent position on the monument. The medallions are brought into relationship by a broad band of laurel leaves. On the back of the monument is placed a trophy composed of a pair of snow shoes, a replica of the cross erected on Observation Hill, and a wreath—relics of the journey. Beneath are Scott's words: 'Had we lived, I should have had a tale to tell of the hardihood, endurance and courage of my companions, which would have stirred the heart of every Englishman.' Forming a base to the pylon is a podium, on the four sides of which are placed bronze relief panels depicting the Expedition. The subjects for these panels are taken from the inscription at Observation Hill: 'To strive' (showing the difficulties surmounted on the journey); 'To seek' (showing the start for the pole); 'To find' (showing the party at the pole); 'And not to yield' (showing the tent covered with snow—the last resting-place of the heroes). The whole monument is placed within a square raised upon steps, the total height being about 37 feet."

The Geological Survey has been issuing its final statistics of the 1913 mineral production which confirms in detail the preliminary estimates issued early in January for the principal minerals. In the large majority of cases these figures tell in one way or another the same story of industrial prosperity. In coal production the increase has been general, and it is this very fact that serves as an unmistakable index of general health in the industrial world. But as state after state is shown to have had its banner coal year—West Virginia, Illinois, Ohio, Kentucky, Alabama, Virginia, Oklahoma, New Mexico, Montana, Texas, Utah and Pennsylvania in both bituminous and anthracite, the record becomes spectacular. Ohio for instance had its floods, yet there was a substantial 6 per cent. increase in coal output, and the miners averaged more working days in 1913 than in 1912. Twelve other states showed increases varying from 3 per cent. in Iowa to 12 per cent. in Indiana and over 15 per cent. in Washington, and only Colorado, Maryland, North Dakota, Nevada, Idaho and Missouri show decreased output, the Colorado labor troubles explaining the only significant decrease. In a similar way, the figures of coke production give large increases, and coke, it may be noted, is a step nearer the metal industry. Petroleum production in 1913 exceeded all records, an increase of 25 million barrels and 72 million dollars over the 1912 returns. In metal mining, the iron and zinc mines had a banner year, while gold, silver, lead and copper showed a decline in many of the largest producing states. Structural materials on the other hand exhibit

marked gains almost without exception. Thus 1913 was the banner year for cement, which gains more than 11 per cent. over 1912, and record outputs are also shown for lime, building sand and gravel, sand-lime brick and glass sand. Other mineral products for which 1913 was a record-breaking year, are bauxite and aluminum, sulphuric acid, feldspar, mica, pottery, and talc and soapstone, while substantial increases are reported for gypsum, phosphate rock, abrasives, barytes, slate and salt. These production figures all express well-maintained activity in mines, smelter, furnace and mill, and prove that the American people are utilizing more of the nation's great natural resources than ever before. A few weeks later when figures are at hand for all of the mineral products, it is expected that 1913 will be found to have overtopped both 1912 and 1907 which have hitherto held the record.

UNIVERSITY AND EDUCATIONAL NEWS

Mr. Asa G. Chandler has given $1,000,000 and citizens of Atlanta have guaranteed $500,000 for the establishment of an Atlanta University, under the auspices of the Methodist Church. It is said that a theological school will be the first to be opened.

Bowdoin College has received a gift of $15,000 from the estate of Dr. Frank Hartley, of New York, to establish a scholarship fund as a memorial to the testator's father, John Fairfield Hartley, of the class of 1829.

The following changes take effect in the botanical department of the Michigan Agricultural College, September 1: Mr. E. F. Woodcock, of the botanical department of West Virginia University, has been appointed instructor in botany to succeed Dr. R. F. Allen, who has recently accepted a similar position at Wellesley. Professor H. T. Darlington, of Washington State College, has been appointed assistant professor of botany and will have especial charge of the botanical garden and herbarium. An industrial fellowship in cucumber diseases has been established by the H. J. Heinz Pickle Company, and is filled by Mr. S. P. Doolittle, who graduated from the institution this year.

In the law department of Tulane University of Louisiana, Mr. C. P. Fenner, professor of Louisiana practise and acting professor of civil law, has been appointed dean of the department to succeed Mr. D. O. McGovney, who has been called to the University of Missouri.

Dr. Nathan Fasten, Ph.D. (Wisconsin), has been appointed instructor in zoology at the University of Washington, Seattle.

Mr. Frederick Soddy, lecturer in physical chemistry in the University of Glasgow, has been appointed to the chair of chemistry at the University of Aberdeen, in succession to Professor F. R. Japp.

Professor J. S. Macdonald, professor of physiology in the University of Sheffield since 1903, has been appointed Holt professor of physiology in the University of Liverpool, in succession to Professor C. S. Sherrington.

Mr. G. N. Watson, M.A., fellow of Trinity College, Cambridge, has been appointed a member of the staff of the department of pure mathematics at University College, London, for the next year to fill the vacancy created by the resignation of Dr. A. N. Whitehead.

Mr. T. B. Johnston, M.B., lecturer on anatomy in the University of Edinburgh, has been appointed to the newly-created office of lecturer and demonstrator in anatomy at University College, London.

DISCUSSION AND CORRESPONDENCE

THE PROBLEM OF GRAVITY

To the Editor of Science: Some recent public utterances from sources that command attention and respect in the scientific world as well as among the general public illustrate rather forcibly the crude and confused state of thought on this subject that continues to prevail up to the present day. These also suggest that the ordinary and obscure thinker need not be deterred from attempting a contribution that may possibly be helpful by the feeling of greatly superior attainments in this

direction by the recognized giants of science. It is axiomatic that a clear conception of what a problem really *is* is a prerequisite to its successful solution. I ask to be permitted to offer the following enunciation:

Neither a quest for an "explanation" of the cause or nature of gravity, on the one hand, nor a mere non-logical acceptance of the fact as a matter of belief or blind faith, on the other, but *the evolutionary development in the minds of men of a scientific satisfaction not only with not knowing but with not ever being able to find out* any rational and consistent theory or explanation for the attraction influence among all portions of matter which is called *gravity* and which is the essential, universal and unalterable attribute of all material things whatsoever.

Obviously such a conception involves rather more of philosophy and psychology than of so-called physical science.

John Millis

A SIMPLE METHOD FOR FILLING AN OSMOMETER

In setting up the type of apparatus ordinarily used in elementary classes to demonstrate osmosis, the thistle-tube is filled with molasses or strong sugar solution. If this is done before the membrane is tied on, the apparatus becomes sticky and the difficulty increased. If, on the other hand, the tube is filled after the membrane is secure, it is very difficult to force the liquid down the narrow stem.

For the last two years I have found the following to be a simple and effective method for filling the tube. Take a perfectly dry thistle-tube, fill it with dry granulated sugar to the flare at the top, and then tie on the wet membrane with a waxed thread. When the tube is inverted the sugar will fill the bulb. With the solution of the lowest layer of sugar in the water of the membrane, the osmotic action is started and the liquid rises in the tube. First observations may be taken when a saturated solution has been formed and no dry sugar remains.

Laetitia M. Snow

Wellesley College

QUOTATIONS

THE PROPOSED UNION OF SCIENTIFIC WORKERS

We continue to receive replies to our notice regarding the emoluments of scientific workers; and they emphasize the opinions which have already been expressed in the leading article of the April number of this *Quarterly*. For example, one worker, a London graduate with first-class honors, who has published original research work and is now a demonstrator working two or three days a week, and who also gives two courses of post-graduate lectures with demonstrations, and does other work, receives the generous salary of fifty pounds per annum—much less than most unskilled laborers will work for. We hear that in one British university, out of two hundred members of the junior staff in all departments (that is all members of the teaching staff who are not full professors), not more than six receive a stipend greater than two hundred and fifty pounds a year. There appears also to be some fear amongst junior staff workers that if they divulge particulars of their salaries they will lose their posts; and in one case we are informed that some highly specialized workers seem even to have lost the ambition ever to earn a reasonable wage. In addition to the poorness of the pay, complaints are made regarding the entire absence of any provision for adequate pension and also regarding the state of serfdom in which men of science are kept under boards and committees composed of persons who frequently have no qualifications for the exercise of such authority. The whole picture is a melancholy not to say a disgraceful one for so wealthy a country, which also imagines that it possesses the hegemony of the world. On the other hand, much sympathy is expressed on behalf of any endeavors that may be made to remedy these evils, and men of science appear to be awakening to the fact that they should attempt some combined effort in this direction. We note especially an excellent article on the "Income and Prospects of the Mathematical Specialist," by Professor G. H. Bryan, F.R.S., in the April number of the *Cornhill Magazine*, and an admirable lecture on the "Place of Science in Modern

Thought," by George Idle, Esq., M.I.N.A., delivered at the Royal College of Science, Dublin, on January 27, which suggests at least the position which scientific work should hold in a modern state. Moreover, the lay press is beginning to consider the subject, entirely with sympathy for the scientific worker; and we should like to give special commendation to the efforts being made by the *Morning Post* in its series of articles and letters published during May and June.

The question now arises as to what had best be done under the circumstances; and it has been suggested that those who wish to do so would be wise to form a union of some kind with a program specifically aimed at improving the position of the workers themselves. At present there are numerous societies which are supposed, more or less indirectly, to attend to this very necessary work, but which certainly have not achieved much success in it. We should therefore like to receive any suggestions upon the subject, together with the names of those who may feel inclined to join such a movement if the program ultimately decided upon meets with their approval.—*Science Progress.*

SCIENTIFIC BOOKS

The Osteology of the Chalicotheroidea, with special reference to a mounted skeleton of Moropus elatus Marsh, now installed in the Carnegie Museum. By W. J. Holland and O. A. Peterson. Memoirs of the Carnegie Museum, Vol. III., No. 2. Pittsburgh, December, 1913, pp. i–xvi, 189–411, with 115 text figures, and plates XLVIII.–LXXVII.

The Chalicotheroidea, a curious aberrant group of Perissodactyl ungulates wherein the hoof bones have departed widely from the normal type, becoming laterally compressed, deeply fissured and claw-like, form the subject of this volume. The Carnegie Museum was fortunate in securing through the efforts of Messrs. O. A. Peterson and W. H. Utterbach an almost complete skeleton of the remarkable *Moropus elatus* Marsh, by means of which the entire osteology of a typical member of the group has been worked out.

The locality of this specimen lay not far from that whence one of Professor Marsh's collectors, H. C. Clifford, secured the somewhat fragmental material which constitutes the type of the species *elatus*. Clifford's discovery in the spring of 1875 was destined to be followed years later, in 1904, by the finding on the upper Niobrara River in western Nebraska of one of the most remarkable bone deposits in the world, the Agate Spring quarry of Lower Miocene age; and it is this locality, which has been worked successively by the representatives of several institutions, Carnegie Museum, American Museum, University of Nebraska, Amherst and Yale, which has produced a number of skulls and skeletons of this type, among them the one forming the basis of this memoir. While Dr. Holland is the senior author of the memoir, Mr. Peterson is credited with the recovery of much of the material, its preparation for study and description and the partial preparation of those sections of the paper which relate to the appendicular skeleton, and to the skull and dentition.

The introductory chapter gives a history of the excavations at the Agate Spring quarries and tells of the conditions of deposition as follows (pp. 194–95):

"The 'Agate Spring quarries' . . . are situated in the Lower Harrison Beds (Miocene) and contain a vast quantity of the remains of extinct mammalia many of which, before the specimens were firmly embedded in the matrix, had suffered more or less displacement. It is rarely that the bones are found collocated in their true order, though in some instances a dozen or more vertebræ may occur in regular series, with the corresponding ribs attached to them, or the bones of an entire limb may be found in place. The region, at the time when the bones were deposited, was probably a great plain, traversed by a broad and shallow river, like the Platte, or the Missouri, subject at times to overflows. It was a region of flat alluvial lands, which may in the summers have been in part dried, leaving here and there pools of water to which the animals

of the region resorted, as in South Africa at the present time herds of ungulates resort to such places. . . . At these pools the beasts, which roamed over the wide plain, came to drink, and here they died, as the result of age, or as they fell under the teeth and claws of carnivora. It may also have been . . . that at this particular point there was a ford, or crossing of the river, much resorted to by migrating herds of animals, and here many, especially younger animals, were mired in quicksands, and drowned."

Chapter I. defines the Chalicotheroidea, sketches briefly the literary history of the group, and names and defines the three subfamilies, Schizotheriinæ, Moropodinæ and Macrotheriinæ; while Chapter II. characterizes the various genera included under each subfamily, both the American and Old World forms, as well as several genera formerly included under the Chalicotheroidea but now referred to other orders and suborders.

In Chapter III. a résumé of the species is given, although, with the Old World types especially, a thorough revision other than of the genotypes was not practicable; at the same time the comprehensive list is of great value for future work. Chapter IV. treats very fully each species of the genus *Moropus*, discussing each one under the several headings of name and synonyms, of what the type consists and its whereabouts, the geological horizon, and the specific characters. The last named includes not only the original description quoted in full, but an adequate supplemental description as well.

Chapter V., embracing as it does 143 pages, is really the *pièce de résistance* of the entire volume, and presents an elaborate morphological study of *Moropus*, based very largely upon the skeleton of *M. elatus* already referred to, which has been mounted in the Carnegie Museum. The assembled skeleton shows certain horse-, rhinoceros- and titanothere-like features, while the feet are so like those of the Edentata as to have been the cause of the inclusion of *Moropus* in that order before the association with other anatomical features was known. The restoration of *Moropus* based upon the articulated skeleton is given in the form of a statuette prepared by Theodore A. Mills under the supervision of the authors, and presents a curious admixture of horse-like head, tapir-like body, and leonine feet. Of its probable habits and the meaning of the peculiar adaptive features the authors are perhaps wisely silent, though a host of questions present themselves upon viewing this grotesque re-creation.

Chapter VI. gives an elaborately studied bibliography, in which the essential facts of each paper are analyzed, showing a very intimate knowledge of the literature of the subject on the part of the authors.

This work, on the whole, is entitled to the highest commendation as an elaborate, painstaking piece of research which will prove of the greatest value to future students of the group, and the fine appearance of the volume is fully commensurate with its importance.

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Atlas und Lehrbuch wichtiger tierischer Parasiten und ihrer Ueberträger mit besonderer Berücksichtigung der Tropenpathologie. By Prof. Dr. R. O. Neumann (Bonn) and Dr. Martin Mayer (Hamburg). Lehmann's Medizinische Atlanten. J. F. Lehmann's Verlag in München. Bd. XI., vi + 580 + 93 pp., 45 colored plates with 1,300 figures and 237 figs. in text, 1914. Geb. M. 40.

The high standard of excellence established in the previous volumes of Lehmann's series of atlases, which includes, among other well-known texts, Sobotta's superb work on anatomy and histology, is well maintained in Neumann and Mayer's recently published "Atlas und Lehrbuch wichtiger tierischer Parasiten." The rapid growth of interest in tropical diseases, the recent expansion of the sciences of protozoology and parasitology, the increasing number of institutions devoted to research in these fields, and the rapid rise of applied hygiene and preventive medicine, have created both the possibility and the need for such a work as this. One has but to glance through the group

of lesser texts which have been issued of late to meet the growing demand for a usable summary for purposes of instruction, to see how large a use has been made in them of old figures which have done duty for decades in older texts, and to be impressed with the wealth of unutilized materials when reference is made to original sources. The time and care needed in the preparation of new illustrations and publishers' reluctance to risk the expense of new cliches and of colored plates is doubtless responsible in part for this situation.

The atlas in hand is far removed from any such criticism, for the thirteen hundred figures on the forty-five colored lithographed plates are from original colored drawings by Professor Neumann, and the publisher has spared neither pains nor expense to insure adequate reproduction, more than twenty colors being employed in some of the plates to bring out satisfactory results. The extensive collections of the Institut für Schiffs- und Tropenkrankheiten at Hamburg have furnished much of the original material upon which the work is founded. Authors have also contributed their original preparations for the preparation of the illustrations. For example, Looss, of Cairo, has contributed hookworm and *Schistosomum* material, Manson filaria, Prowazek trachoma, and Chagas his Brazilian *Schizotrypanum*, the causative agent of the South American "sleeping sickness." Japan, Ceylon, Cairo, Congo, Nigeria, Brazil, the Schools of Tropical Medicine in Hamburg, Liverpool and their outposts in the tropics have contributed richly to the resources utilized in this work.

It has been the aim of the authors to include all forms of clinical importance and such other related forms as are of theoretical interest. The work was instituted in 1905, but the growth of the subject has been so rapid that its publication has been delayed, with the result that the work has been greatly enriched by recent discoveries. Obviously no book of even the sumptuous form of this atlas could be expected to be encyclopedic. A vast deal of elimination of detail, of selection of material which has passed to the stage of reasonable certainty, and the omission of that of more problematical status has been essential. The authors have been very skilful in this respect, though one questions their inclusion of Prowazek's figure of "conjugation" in *Trypanosoma*, for it would seem that the evidence for sexual reproduction in the trypanosomes is as yet inconclusive.

The book unites the fields of zoology and medicine and has been written with both in view, though naturally many details of systematic, cytological and anatomical nature are eliminated, or presented only in condensed form. On the other hand, life-histories of the parasite and its carrier-host, and the pathological conditions which it induces, are subject to both discussion and illustration.

The structure of the elements of normal blood is very fully illustrated and the technique of hematology is elaborated and methods of staining, preservation, culture, collecting and sending parasitological material are detailed, usually with figures illustrative of apparatus and method. References to literature are well chosen and ample. Considerably more than half of the work is given to the Protozoa and to their invertebrate hosts, the flies, mosquitoes, bugs and ticks, five plates being devoted to trypanosomes and no less than five to the malarial parasite. It is perhaps because of this wealth of protozoological illustration that one gets the impression that the parasites belonging to the higher phyla, the worms and arthopods, have received, relatively to their importance, less ample treatment. But to have done more would have inevitably necessitated a second volume. It also seems that the parasitic flagellates, other than trypanosomes, and ciliates call for fuller treatment than has been accorded them.

While the emphasis is placed upon human parasites, the treatment is not restricted to them; the additions, however, are more by way of biological inclusiveness than for the purposes of comparative medicine. The work can hardly serve the purposes of the veterinarian, though indispensable in all fields of parasitology.

The authoritative character of the work, the

accuracy, completeness and utility of the illustrations to the clinician and practitioner, the broad biological conception underlying the treatment, combine to characterize the work as the best iconography of parasitology as yet published.

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THE RELATION BETWEEN LIZARDS AND PHLEBOTOMUS VERRUCARUM AS INDICATING THE RESERVOIR OF VERRUGA

IT affords the writer much satisfaction to record another confirmation of the intimate relation which exists between *Phlebotomus* and lizards or other reptiles the world over. Many cases of this relation have been recorded in the recent literature, and the same appears to hold good in Peru.

Numerous blood smears made during the past two or three months from small rock lizards of several species collected at Verrugas Canyon, Surco, San Bartholomé and Chosica Canyon all show rod and granule bodies which exhibit the identical morphology of the bodies that have been named *Bartonia bacilliformis.* Their agreement with the latter in shapes, sizes, colors and apparent structure is so faithful as to defy distinction. The lizards concerned have been sent in for identification.

It is to be noted that the first three localities above mentioned are well within the limits of the verruga zone of the Rimac Valley, while Chosica Canyon is just outside that zone. Lizard blood smears made in Chosica Canyon in June, 1913, and again recently all show these bodies, but the granules seem to predominate greatly in the blood of the lizards from outside the verruga zone and from points within the zone where the lizards are not exposed to the constant attacks of the *Phlebotomus.*

In Verrugas Canyon there are, close to the house, many large walls built of loose rock wherein the *Phlebotomus* hide in swarms during the day, issuing in the evening to enter the house and bite the inmates. These rock walls are also inhabited by the small lizards in question. Smears of blood made from lizards from these walls show a great predominance of the rods over the granules. These lizards are exposed to the constant attacks of the *Phlebotomus* every day in the year.

The writer has found the same bodies in smears made from the *Phlebotomus* at Verrugas Canyon, which also show the nucleated red corpuscles of the lizards as well as mammalian erythrocytes. The same rods and granules have furthermore been found by the writer in microtome sections of human verruga papules, in similar sections of papules produced in his laboratory animals by injections of the *Phlebotomus,* and in the blood of these animals prior to the eruption.

Blood smears of a young guinea-pig taken $63\frac{1}{2}$ hours, and later, after injection subcutaneously with a very small quantity of citrated lizard blood from Chosica Canyon have shown the typical granules and Bartonia rods in the disks of the erythrocytes. This pig died nine days after injection, after irregular rises of temperature, and its autopsy blood and femoral marrow showed a large increase of the bodies, principally granules but also short rods.

Subcutaneous injection of a second young guinea-pig with a larger quantity of citrated lizard blood from Surco proved fatal within ten hours, liver smears showing the rods and granules, but blood, marrow and spleen smears proving practically negative. Further experiments of a similar nature are under way. The three-cornered connection, however, between lizards, *Phlebotomus* and verruga appears to be already well established by these data.

It is seen from the results that this possible reservoir of verruga in the lizards is not confined to the verruga zones, which are limited by the occurrence of the *Phlebotomus,* but may exceed the latter in range. This explains how fluctuations in occurrence of the *Phlebotomus* may result in extensions or retractions of the verruga zones, the gnats finding the infection at hand on gaining a new locality.

It also seems indicated by the above results that the verruga organism must exist in the infective stage in the lizard blood and does not apparently demand the medium of the *Phlebo-*

tomus for its development but only for its transfer to new hosts. Thus the *Phlebotomus* appears to be merely a mechanical transmitter of verruga, and not a true secondary host of the organism. But it is probable that the gut of the *Phlebotomus* favors the free liberation of the infective stage of the organism, which either penetrates thence to the salivary glands or passes directly forward through the alimentary canal, by regurgitation or otherwise, to the pharynx and thus gains the proboscis.

It seems demonstrated by the above findings that these small rock lizards constitute at least one reservoir of verruga. Whether snakes, man or other mammals constitute additional reservoirs of the disease remains to be determined. The writer puts forth the tentative opinion, subject of course to future modification, that lizards and possibly snakes, in other words reptilian animals of cold blood, may yet be found to constitute the sole reservoir of verruga. It seems quite possible that *Phlebotomus* can not become infected with verruga from the blood of mammals, but this point needs careful investigation.

As bearing on this view, it is to be noted that no one has yet succeeded in making cultures of the Bartonia bodies from human blood, and that injections of mammalian blood containing these bodies have given only negative results thus far. The verruga organism might be looked upon as outside its natural environment in mammalian blood, but at home in reptilian hosts. Nevertheless it is quite possible that it has been overlooked in the experiments after making the injections of Bartonia containing blood referred to.

The above rods and granules have also been found by the writer in the bone marrow, liver and spinal cord of the lizards, as shown by smears from these organs. In the blood of the lizards the rods and granules are often free in the plasma but frequently in or attached to the surface of the red corpuscles. They stain with Giemsa characteristically brownish, sometimes bluish or reddish, exactly as do the Bartonia. If these organisms are not identical with the Bartonia, they are certainly very similar morphologically and evidently bear a constant relation to verruga. It has not been possible as yet to attempt cultures of these bodies with the view of demonstrating their nature, owing to lack of both time and facilities. They may easily turn out to be the bacillus paratyphoid B, in large part at least, but in any case they seem linked with Bartonia in some thus-far mysterious relation.

There is quite a large possibility that the Bartonia may prove to be simply the lizard-blood bodies parasitized by the verruga organism proper. From 1900 to 1902 Barton demonstrated the bacillus paratyphoid B in all his verruga cases, and with it he produced the fever and eruption in both dogs and mules. Since this bacillus is so constantly present in verruga cases it seems certain to the writer that it bears some important relation to the disease. As it has been cultivated with ease, while Bartonia has not, it may well be the case that the latter is simply an infected form of it which has lost its reproductive power. In such event the verruga organism does not reach the infective stage until the Bartonia containing it has broken up naturally and disappeared. Barton's animal experiments seem strongly to indicate that the bacillus paratyphoid B carries verruga infection.

Similar cases of the constant attendance of certain bacilli upon diseases of obscure etiology, as yellow-fever, hog-cholera, etc., are well known. It may well be that such bacilli are infected with the respective ultramicroscopic organisms of these diseases and play an important rôle in their carriage.

Whether the intracorpuscular bodies found by Laveran and Carini in the blood of lizards are of the same type as the present rods and granules remains to be seen. It would seem quite likely that the two may be closely related. The present bodies, which are only tentatively assumed to be Bartonia or to metamorphose abnormally into the latter, exhibit much resemblance to Theileria. The granule stage also approaches the marginal-point stage of Anaplasma, and is very similar to the stages figured by Anderson for the Rocky Mountain spotted-fever organism, which is probably not a Piroplasma.

Blood smears of a native rat, probably a species of *Euneomys,* caught at Verrugas Canyon, have shown nothing definite. Smears of the blood of dogs and burros, doves and ground-owls from the same locality have likewise proved negative. The vizcachas, *Viscaccia* spp., are contraindicated as a reservoir of verruga. It has not yet been practicable to secure vizcacha blood smears from the verruga zone, but these animals do not occur close to the house in Verrugas Canyon, where the *Plebotomus* is very abundant in the rock walls, which it evidently leaves only to enter the house or attack persons and animals close by. Therefore these particular gnats are precluded from deriving their infection from the vizcacha, and they are well known to be infected at most times if not continuously.

In conclusion it may be pointed out that, on *a priori* grounds, the inference is logical that the lizards constitute a verruga reservoir. The *Phlebotomus* passes the daylight hours within the darkened recesses of the loose stone walls and piles of rock in order to escape wind and strong light. Lizards inhabit the same places, finding their food there and coming out only briefly at rare intervals to sun themselves. The *Phlebotomus* is always ready to suck blood in the absence of light and wind, and has been found more prone to suck reptilian than mammalian blood. Nothing is more natural than that the *Phlebotomus* should suck the blood of the lizards to a large extent during the day, and this is what actually happens. If the *Phlebotomus* carries verruga, and this is already demonstrated to be the fact, it follows that the lizards must become infected therefrom even if they were not originally so. That they are probably the original reservoir of the disease is indicated in general by the constant host relation which obtains between *Phlebotomus* and reptiles the world over and specifically by the mutual habitat of the two which has resulted in their being thrown continually together since their existence began.

CHARLES H. T. TOWNSEND

CHOSICA, PERU,
April 27, 1914

SPECIAL ARTICLES

ON THE ANTAGONISTIC ACTION OF SALTS AND ANESTHETICS IN INCREASING PERMEABILITY OF FISH EGGS (PRELIMINARY NOTE)

IN previous papers[1] it was shown that pure salt solutions and nicotine increased the permeability of fish eggs and that these permeable eggs developed abnormally, giving rise to cyclopia and other abnormalities common to fish embryos. During the present season I have observed a few cyclopic or one-eyed pike embryos in the hatching jars of the State Fish Hatchery, St. Paul, Minnesota. Eggs of the pike and muskalonge were found to live in water re-distilled in quartz and to be adaptable to permeability experiments. Pike eggs were used, and although they were not as impermeable as Fundulus eggs, they were normally but very slightly permeable to salts. They were placed in distilled water and in solutions of anesthetics or of sodium nitrate, and the chlorides diffusing out of them estimated quantitatively with the nephelometer. Except for the use of the nephelometer, which admitted of a quantitative estimation of very minute quantities of chlorides, the technique was the same as given in the previous papers. If one or more eggs died in an experiment, it was repeated. Pike eggs will live in 3 per cent. alcohol for many days and in 6 per cent. alcohol for a considerable length of time.

Six per cent. alcohol, or $\frac{1}{3}$ saturated (more than 1 per cent.) ether, or $\frac{1}{10}$ molecular sodium nitrate increased the permeability of the eggs. This change was irreversible, but did not kill the eggs—after the eggs were put back into distilled water they remained permeable.

When a salt and an anesthetic were combined in the same solution, it was found that the anesthetic antagonized the action of the salt. This antagonism was not very marked, but seemed to be constant. The method of procedure is shown by the following example: A mass of pike eggs was divided into three exactly equal lots. Lot 1 was placed in 50 c.c. $\frac{1}{10}$ molecular $NaNO_3$. Lot 2 in 50 c.c. $\frac{1}{10}$ molecular $NaNO_3$ containing 3 per cent. alcohol.

[1] McClendon, SCIENCE, N. S., Vol. 38, p. 280; and *Internat. Zeitsch. f. Physik.-Chem. Biologie,* 1914, Vol. 1, p. 28.

Lot 3 in 50 c.c. $\frac{1}{10}$ molecular $NaNO_3$ containing $\frac{1}{2}$ per cent. ether. At the end of eight hours, the water was removed from each lot, evaporated in quartz vessels to 3 c.c. and examined with the nephelometer. The water from lot 2 contained $\frac{1}{2}$, and that from lot 3 contained $\frac{3}{4}$ as much chlorides as that from lot 1.

Two conclusions may be drawn from these experiments.

1. Pure salt solutions or anesthetics, in concentrations approaching the lethal dose, irreversibly increase the permeability.

2. Anesthetics in about $\frac{1}{2}$ the above concentration (which is about the concentration for narcosis) antagonize the action of pure salt solutions, so that the combined action is less than the action of the salt alone in increasing permeability.

It has been shown that the permeability of muscle is increased by stimulation.[2] Anesthetics in certain concentrations tend to inhibit the stimulation of muscle. Perhaps they do so by inhibiting the increase in permeability. This idea is not new, but new facts are brought in support of it.

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June 1, 1914

THE EFFECT OF SOIL CONDITIONS ON THE TASSELS OF MAIZE

Considerable work has been done on the effect of various factors of environment on the growth of the maize plant. Most of these studies have been confined to the pistillate flowers, or the ear, and comparatively little attention has been given to the tassel which produces the pollen.

Lazenby,[1] on studying a number of varieties of corn, showed that the number of flowers upon a stalk varied widely even in the same variety. He also found a certain relation between the number of pistillate and staminate flowers produced by the corn. This relation was not the same for all types.

In work carried on at the Utah Experiment Station by the author and his associates on the effect of soil factors on plants, a study was made of the number of branches produced in the tassels of maize.

The corn was raised at the Greenville experimental farm on a uniform soil that had received no manure for many years previous to beginning this experiment in 1911. There were 36 plats in all, 12 having no manure applied, 12 receiving at the rate of 5 tons to the acre and 12 receiving 15 tons. The size of each plat was 7 x 24 feet.

Each manuring treatment contained six different irrigation treatments of two plats each as follows: (1) no irrigation, (2) 5 inches, (3) 10 inches, (4) 20 inches, (5) 30 inches and (6) 40 inches. The water was applied in irrigations of five inches each. When the plants were a few inches high they were thinned so that each plat contained the same number of plants.

Before harvesting a count was made of the number of branches in the tassel of each plant and averages made for the plats. A record of the number of ears produced on each plat was also made. The work has been carried on for three years. A summary of the results follows:

EFFECT OF MANURE ON THE NUMBER OF BRANCHES PER TASSEL OF MAIZE

Manure Applied	Number Plats Each Year	Number of Branches per Tassel			
		1911	1912	1913	Average
None	12	15.45	12.85	13.65	13.98
5 tons	12	17.29	14.89	18.61	16.92
15 tons	12	18.75	16.09	21.47	18.77

The number of ears produced on each plat was as follows:

Manure Applied	Number of Ears per Plat			
	1911	1912	1913	Average
None	70	59.25	49.3	59.52
5 tons	75	75.41	66.5	72.30
15 tons	75	78.08	83.5	78.86

[1] Lazenby, W. R., "The Flowering and Pollination of Indian Corn," *Proc. Soc. Prom. Agr. Sci.* (1898), pp. 123–129.

[2] McClendon, *Am. Journal Physiology*, Vol. 29, p. 302.

In order to compare the number of branches per tassel with the ears per plat, 100 was taken as the number on the plats with no manure in each case, and the others expressed in relative numbers.

RELATIVE NUMBER OF BRANCHES PER TASSEL AND EARS PER PLAT

Manure Applied	1911		1912		1913		Average	
	Branches per Tassel	Ears per Plat	Branches per Tassel	Ears per Plat	Branches per Tassel	Ears per Plat	Branches per Tassel	Ears per Plat
None....	100	100	100	100	100	100	100	100
5 tons...	112	107	109	127	129	127	121	121
15 tons.	115	107	125	132	157	160	127	132

The effect of the irrigation water on the number of branches per tassel and the ears per plat is expressed in the following table, which is an average of the three years' results.

EFFECT OF SOIL MOISTURE ON THE NUMBER OF BRANCHES PER TASSEL AND EARS PER PLAT

Water Applied	Number Plats Each Year	Number Branches per Tassel	Number Ears per Plat	Relative Number of	
				Branches per Tassel	Ears per Plat
None.........	6	16.25	69.28	100	100
5 inches.....	6	16.78	76.05	103	110
10 inches...	6	16.33	71.27	101	103
20 inches...	6	16.49	77.38	102	112
30 inches...	6	17.15	73.28	106	106
40 inches...	6	16.56	75.28	102	109

These tables show that the number of branches per tassel is affected by the condition of the soil, and that there is a close relationship between the tassel branches and number of ears produced.

It seems clear, therefore, that the staminate and the pistillate flowers of maize are affected by the same conditions.

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ASCARIS SUUM IN SHEEP

AN autopsy of an eight-months-old lamb upon which with others of the same age, a feeding experiment was being conducted revealed the presence of two female ascarids in the small intestine. By the aid of the key in Ransom[1] these were diagnosed as *Ascaris ovis.* These lambs, however, were being fed and kept in pens, previously occupied by hogs, known to be infested with ascarids. The pens had been thoroughly cleaned out before the lambs were placed in them. An examination of the ascarids in the light of this information emphasized their close similarity if not idenity to *Ascaris suum.*

The mothers of these lambs were shipped up from the Carpenter Test Farm in the spring of 1912. No ascarids have ever been found in the sheep on this farm. The examination of the feces of the ewes from which these lambs were raised has never revealed the presence of ascarids. It appears highly probable, therefore, that the lamb got its infestation from the pen in which it was kept and that the eggs from which the worms developed were deposited in the pen by the infested hogs which previously occupied it.

The status of the different species of ascarids affecting man, swine and sheep seems to be somewhat in question. It is considered questionable by some authors whether *Ascaris ovis* (sheep) represents a distinct species, or whether it is simply *Ascaris lumbricoides* (man) or *Ascaris suum* (pig) in an unusual host. Circumstantial evidence in the case here recorded strongly indicates that this statement may be true. It is also questioned by some whether *Ascaris suum* and *Ascaris lumbricoides* represent distinct species. In fact, Neveu-Lemaire[2] does not consider the differences between these worms marked enough to establish a separate species and reduces *Ascaris suum* Goeze, 1872, and *Ascaris suilla* Dujardin, 1845, to synonyms. He calls the ascarids of these two different hosts *Ascaris lumbricoides* Linne, 1758. Feeding experiments may serve to clear up this confusion.

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[1] Ransom, "The Nematodes Parasitic in the Alimentary Tract of Cattle, Sheep and other Ruminants," 1911.

[2] M. Neveu-Lemaire, "Parasitologie des Animaux Domestiques," 1912.